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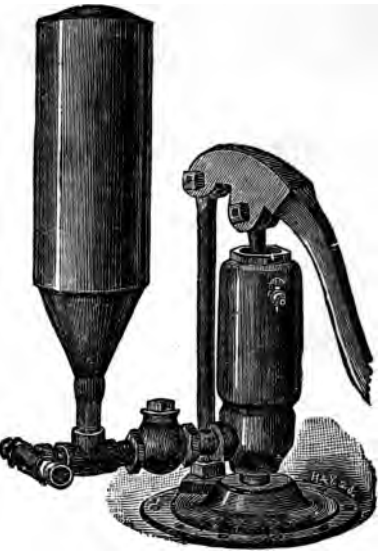

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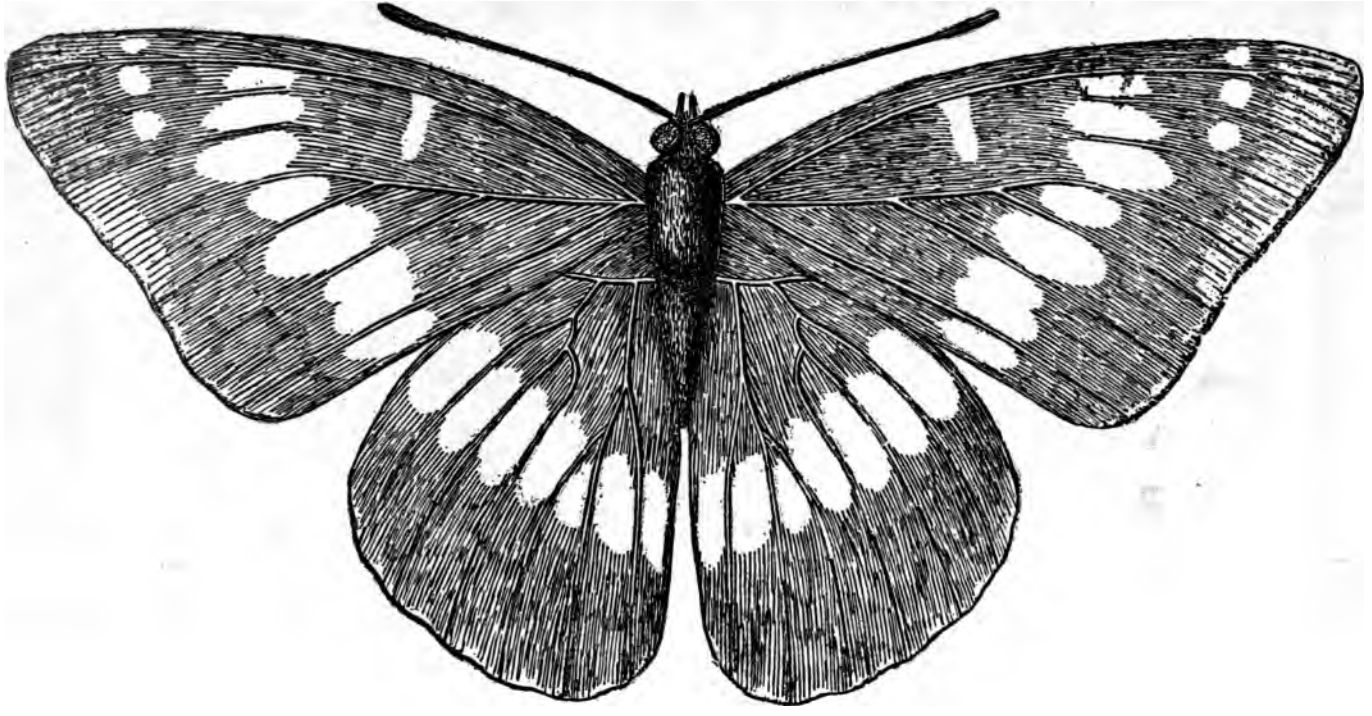

THE GLORY OF THE MORNING.—(Enlarged.)

STUDIES IN ENTOMOLOGY

A PRACTICAL WORK ON INSECTS, CONTAINING SUGGESTIONS AND OUTLINES FOR NATURE-STUDY IN SCHOOL WORK.

—BY—

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1899
THE WHITAKER & RAY COMPANY
(INCORPORATED)
SAN FRANCISCO, CAL.

I.

INTRODUCTORY.

"He prayeth best, who loveth best
All things both great and small;
For the dear God, who loveth us—
He made and loveth all."

—Coleridge.
From "The Ancient Mariner."

A knowledge of this and the succeeding pages of this chapter will add interest to the sketches which are to follow, as well as explain many terms which might not otherwise be clear. Especially is it to be desired that the reader understand the anatomy of the grasshopper, as that insect is taken as a type of insect structure.

The first work of the young entomologist is collecting. On your trips catch everything that's alive, has legs, whose body is made up of segments or rings, and that is not too large. A large-mouthed bottle will do at first to carry your specimens in. Do not handle an insect unless you know it to be harmless. Care should be used with all poisonous spiders, should you become interested in them. Butterflies, dragon-flies, bees, wasps, flies, etc., can be caught with a net made cheaply as follows: Take a piece of wire at least forty-two inches long. Bend it into a circle thirty-six inches in circumference, allowing the ends to lap; three inches from each end of the wire bend it outward so that the three-inch parts shall be in line with the diameter of the circle at the point where the bends are made. These two ends are now inserted into a wooden handle and secured by a ferule. The handle should be from four to six feet long. A mosquito netting sack, having the same diameter as that of the wire circle,

should now be made. Sew the wire circle to the open end of the sack and the net is ready for use. A larger or smaller net may be made by using different proportions for the diameter, etc. Directions for making a more substantial net may be found in Part F of Bulletin of the U. S. Museum, No. 39, pp. 27-35, inclusive.

Various devices are used for killing insects preparatory to mounting. Covering them in a bottle with a few drops of chloroform will do the work. The best device—one which will not injure specimens to any great extent—is the "Cyanide Bottle." This is made by covering a few lumps of the cyanide of potassium, placed in the bottom of a large-mouthed bottle, with plaster of Paris. Set the plaster of Paris with water. Let the apparatus dry. Enough of the poisonous fumes of the cyanide will pass through the plaster to quickly kill any insect dropped into the bottle. When not in use the bottle should be kept tightly closed. While cyanide of potassium is a deadly poison, there is practically no danger from the cyanide bottle unless the fumes are directly inhaled. Some soft substance, such as strips of fine tissue paper, should be placed in the bottle, to prevent specimens from injuring themselves. A bottle in which pounded laurel leaves have been placed may be used for killing insects. It is, however, not so effective as the cyanide bottle.

Liquid ammonia placed on a small sponge in a tin canister may be used to kill small butterflies and moths. If the insects are delicately colored, especially those of red or pink and green, the ammonia should be replaced with alcohol or chloroform.

The word "Poison" should be plainly written upon the cyanide bottle, as well as upon other bottles containing poisonous substances used in your work.

For care of your insects you will need some insect pins. Nos. 1, 2, 3, 4 (Klager numbers), are the ones best suited to general work. You will need some cork in sheets—cork linoleum is perhaps the best—a pair of sharp pointed scissors, some small forceps,

a small hand lens, some chloroform, and a number of cigar-boxes for a temporary cabinet. You should also have a supply of homoeopathic bottles in which to place those specimens which may be best preserved in alcohol. Several needles provided with suitable handles will also be found convenient in mounting or in examination of specimens. How to make a more elaborate cabinet is explained in the Smithsonian Bulletin, described above. A "setting-board" may be made of soft wood five inches wide, twelve or more inches long, and an inch thick. A groove half an inch deep and half an inch wide should be cut in the middle of the board for its entire length. Cover the rectangular faces of the board on each side of the groove with cork or cork linoleum. The width of the groove may be varied to suit the size of the insect.

To set, for example a butterfly, first drive the insect-pin vertically through the middle thorax of the dead specimen. Arrange the legs so that they can be easily observed, without concealing the under parts of the body. Put the antennae in their natural position. Now place the specimen feet downward in the groove of the setting-board. Spread the wings out over the sheets of cork so that all the parts of each wing may be seen. Fasten them with strips of pasteboard held by pins driven through the pasteboard into the cork. Leave the insect in place until it is thoroughly dry—say from four days to a week. The specimen will then be ready for the cabinet.

A careful observance of the following points will add to the appearance of the specimens. Drive the pin through the insect so that it will protrude from below the same distance in every specimen. This is to insure all specimens to stand on the same level in the cabinet. Let the pin protrude from below far enough so that there will be room enough upon it for small cards upon which records may be written. Pin beetles through the right wing cover. Pin bugs (heteroptera) through the scutel —the triangularly shaped place just behind the thorax. Other

insects are pinned as is the butterfly—through the middle thorax.

Ordinary corks of equal sizes may be glued to the bottom of your cabinet. In these are to be inserted the pins which hold the insects firmly in their final resting-place. Sheets of cork may take the place of the common corks, or better yet, the cabinet may be lined with cork linoleum. A less expensive method of fastening the insects in the cabinet is as follows: Fit a frame one-half an inch deep into the cabinet. Over this paste a strong piece of paper, so that it will be tight like a drumhead. On the opposite side of the frame paste in like manner a second sheet of paper. When the frame thus finished is placed in the cabinet-box it takes the place of the cork. When a pin is driven through the two paper drumheads and slightly into the floor of the box, the specimen is securely held. This contrivance has several advantages. The frame is easily removed and the cabinet is thus easily rid of insect pests. The space next to the floor of the box may be used for insecticides, which are thus concealed from view.

Insects that have crumpled when drying or that have become too dry to mount, may be relaxed or softened by placing them in a tight tin vessel about half full of moist sand. A few drops of carbolic acid should be added to the sand to prevent molding. Small insects should be left in the box about twenty-four hours; larger insects require two or three days. A more rapid relaxing process is by use of steam. The specimens are fastened to a sheet of cork which is floated upon hot water in a closed tin box.

Small beetles may be gummed with strong, colorless glue to wedge-shaped or rectangular bits of paper. The insect is placed on one end of a strip of paper. The insect-pin is then placed in the other end and driven into the cork in the cabinet. Small specimens may be mounted in duplicate by placing a number of them, gummed to strips, upon the same pin. Very small butterflies, moths and flies may be first impaled on very fine pins,

which are thrust into small pieces of cork cut into the shape of square or triangular prisms. The corks are in turn mounted upon larger pins. Phials containing specimens preserved in alcohol or formalin may be arranged in wooden racks specially made for the purpose. The test-tube rack found in any chemical laboratory will give a hint as to the manner of making these. For the more difficult process of inflating larvae a more technical work than this should be consulted.

It is very desirable to have at your home a number of glass jars or globes in which you may place aquatic specimens for observation. A large fish globe will be useful for some of the large insects, such as the nymphs of dragon-flies. Mosquitoes can best be observed in thin beaker glasses, such as you can get from any chemist. An aquarium made of thin plate-glass, such as will not magnify or distort, is very useful in conducting a series of observations such as one might wish to make upon dragon-flies or upon such hemiptera as water-boatmen.

A wooden box with holes in it, over which have been placed mosquito netting or wire screening, may be used for rearing caterpillars for purposes of observation. Place some damp sand in the bottom of the box to supply moisture. Cover the box with a plate of glass. The caterpillar should be supplied with the food which you find it eating when you capture it. Other conditions of its native haunts should be supplied as nearly as possible.

It is often convenient to store specimens, which you have taken upon an extended trip, temporarily. This may be done, especially with lepidoptera and neuroptera, by folding the wings of the insect so that the lower surfaces meet, and then placing it in a triangular envelope. The antennae should also be folded downward. When cared for in this way the specimen may be readily sent through the mail. When carrying a number of insects so packed it is well to keep with them a supply of naptha-line as an insecticide. Larvae may be sent through the mails in

tin boxes, as nearly air-tight as possible, since insects are not easily smothered, and the tightness of the box will prevent the rapid drying of the leaves or other food which you put into the box.

Each specimen in your collection should have a label, which should contain the following points: An indication of the exact locality in which the insect was found, the date of capture, the sex of the specimen, the name of the collector, the specific name of the insect, a reference to other and more voluminous notes which you have recorded in a commonplace book. The notes last referred to should consist of life-history, food of the insect, habits of flight and any other notes which you may think of interest.

If you wish to become very proficient in collecting and preserving insects, procure, if possible, "Part F," Bulletin 39, United States Museum, Washington, D. C.

In your excursions in search of hexapods or insects you will soon find that there are many other life forms the outer framework of whose body is made up of rings. You will find numberless of these as you wander over marsh lands or when you dig in the seashore sands, or clamber over the moss-grown rocks of low tide. You will find them among the rafters of old barns. You will see their swinging nests among garden rose-bushes. You will find them under the bark of decaying forest trees, and catch glimpses of their shining forms every time you lift an old board. All of these are not insects. Some may be the near relatives of insects.

There are three different branches in these near relatives of insects. One is represented by crabs and lobsters, another by the spiders; still a third branch is commonly known as the thousand-legged worms, or myriapods. "How are we to know when we really have found an insect?" you say. Well, to answer briefly, insects, as you will soon know from your study of the grasshopper, have but six legs, while spiders have eight legs, crabs

and lobsters have from ten to fourteen legs, and myriapods have more than fourteen legs. These differences will be sufficient to enable you to collect without confusing your insect specimens with any of the groups mentioned above. The fact that nearly all hexapods have wings in the adult stage of their lives will enable you to recognize them quickly. With this leg test and wing test you will have but little trouble in recognizing the full-grown insect, and while after some experience you will have no difficulty in recognizing the insect as such in the younger stages of its growth, you may find it necessary to keep some of the more wormlike or larval forms till they are grown in order to be certain that they are insects. Worms or vermes are distinguished from all arthropods, a name by which all hexapods, spiders, crabs and lobsters, and myriapods are collectively known, by the fact that worms have no legs.

Insects have their haunts and their feeding places just as other animals. In springtime a warm, sunshiny nook containing a variety of plants and flowers is sure to be the home of butterflies. If near the water dragon-flies will also come there to prey on the numberless smaller insects which are also always found where there are flowers. The young insect-collector will be delighted at what he can find amongst anise beds, teasles, wild licorice and milkweed. Thistles growing in a protected, sunshiny spot are sure to attract certain kinds of butterflies.

Night-fliers, moths and beetles can be found in large numbers at night about electric lights. In fact, many moths and beetles will at night fly blindly into an ordinary light, when they may be easily captured. Ravines, rivulets and creeks are good fields for the young collector to explore; nor in these trips should he fail to turn over old logs and stones, as by looking under these many a beginner, who has thought himself to be entirely out of luck, has found himself suddenly enriched with the rarest and most shining insect treasures. In autumn every

old fence and outbuilding should be inspected for cocoons and chrysalides.

I will suggest that after you have made a close study of the grasshopper a collecting expedition be made in which, as I have said before, you will catch everything that's alive, has legs, whose body is composed of rings, and is not too large. On such a trip you will need your insect net, your cyanide bottle, some pill boxes, and larger pasteboard boxes in which to place the insects after they have been killed. You will need some small bottles, such as those in which we get homoeopathic medicines. These are to be filled with alcohol, and in them are to be placed caterpillars and grubs and specimens which you can readily see will not retain their shape if allowed to dry. You will need your hand-lens. Finally, do not forget several large bottles in which to put aquatic specimens. These you will want to carry home alive. Visit patches of milkweed, anise beds, clumps of thistles, teasles and wild licorice, sunny gardens, old creek beds, streams and rivulets. Look under stones, old boards and logs. See what you can get by dredging ponds and rivulets. Keep a sharp lookout for queer forms hanging to fences and hedge-rows, clinging to eaves and to corners of deserted sheds and outhouses. Scour the meadows and orchards. Scan the bark of trees and backs of leaves for insect eggs. Be sure to take home some stagnant water containing "wiggle-tails." These you can easily find if nowhere else in an old rain-barrel.

On this your first collecting trip it would be well for you to secure a spider and a thousand-legged worm; also one of those little dove-colored creatures known as sowbugs. The last is always found under boards or logs in cellars and other damp places. Make a careful study of these common forms of arthropods in order that their chief features may be clear in mind. Notice especially the number of legs on each.

II.

THE GRASSHOPPER.

Using the net described on page 5 of this book, capture twenty or thirty large grasshoppers. There will be no trouble in finding them, as they may be seen in summer or fall in any field. Kill the insects as directed on page 6. Select from your specimens those which have the following points in common: A black spot extending towards the tail from the eyes; a row of brownish spots along the middle of the front pair of wings; legs, red or marked with red; general color, a mixture of dirty olive and brown; on each side of the body, a yellow line extending from the point where the wings join with the body to the hind leg. The specimens thus chosen will without doubt be the red-legged locust known scientifically as Caloptenus Femur-rubrum.

Close observation will show you that there are two kinds of grasshoppers among those selected, one whose tapering "tail" ends in four prongs (this is the female), and one whose tail somewhat increases and ends in quite a large "hood-shaped" plate (this is the male). We will select the largest female for our work.

Notice that the body of the grasshopper is made up of rings. This ring structure is clearly seen in the "tail." It is this structure that is common to all articulates. The body of the grasshopper, it will be seen, has three divisions—the head, the thorax, to which are attached the wings and legs, and the abdomen or tail. The head appears to have but one segment or ring, the thorax has three divisions or rings, and the abdomen a number of rings, from eight to eleven, according as we consider the

caudal or tail parts as separate rings or merely appendages of other rings. It is probably more correct to count the abdominal parts as eleven.

The hardness of the body wall of the grasshopper is due to the deposit in it of a substance known as chitine. Were it not for chitine the grasshopper's body would be defended by a soft membrane instead of the hard plates which give it such substantial protection. In fact, it is to chitine that all insects owe the hardness of skin which makes for them an outer skeleton.

The head is joined to the thorax by a soft, pliable membrane. This may be seen if we pull the grasshopper's head out as far as we can without pulling it off. In the membrane at this point but little chitine is deposited. Thus, chitine is not regularly deposited throughout the body wall, but a close examination will show that the body wall or skin seems to be made up of a number of plates or pieces. The skin is, however, really continuous, and the plates are but portions of it in which an unusual amount of chitine is deposited. A single one of the chitinized plates above referred to is called sclerite. The narrow, soft portions between the sclerites are known as sutures. Sometimes the sutures do not exist, being entirely filled in with the hardening substance chitine. In this case the sutures are said to be obsolete.

The head of the grasshopper consists of chitinized plates firmly joined together. In this box is the brain or chief nervous center of the insect. The most wonderful and most beautiful parts of the head are the eyes. The most easily seen of these are two large hemispherical objects, the compound eyes, situated on each side of the top of the head. Under a compound microscope, one-half inch objective, can be seen the exquisite structure of the eye-parts. What at first to the naked eye appeared to be single is, under the microscope, found to be composed of a multitude of smaller eyes. Each is hexagonal in shape and each fitted to

the other as in a piece of mosaic. This honeycomb-like structure of the grasshopper's eyes is shown in figures 1 and 2.

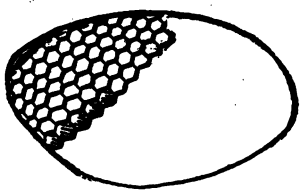


Fig. 1.

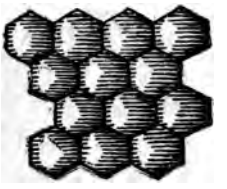


Fig. 2.

Besides the compound eyes there are three simple eyes. With your hand lens find these. Close to each compound eye on the inner side is to be found one simple eye. There is a third simple eye looking directly to the front. It is between the two compound eyes, but much further down towards the mouth. Simple eyes are termed ocelli; singular form, ocellus. The term eyes is always used with reference to the large compound eyes.

All of these statements concerning the grasshopper, as well as those to follow, should be carefully verified by actual examination of the specimen.

The large sclerite which surrounds the eyes, and in which are placed the simple eyes, or ocelli, is known as the epicranium (figure 3.) It makes up the greater part of the covering of the head. The upper part of the epicranium is called the vertex; that part between the compound eyes and the mouth is called the front; the side parts of the epicranium are known as genae or cheeks. By boiling the head of a grasshopper in a solution of caustic potash other sclerites of the head may be traced, together with the sutures which separate them. Show that there are four of these sclerites in the head.

We now come to the movable parts of the head. These are the antennae and the organs known collectively as mouth parts. The long, thread-like, many-jointed antennae are situated on the imaginary lines joining the ocellus or simple eye, which is on

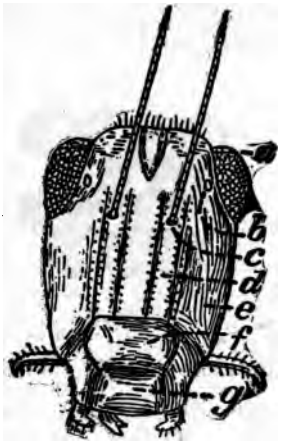


Fig. 3.

a—Compound eye.
b—Ocellus.
c—Antenna.
d—Antennary fossa.
e—Epicranium.
f—Clypeus.
g—Labrum.

Fig. 4.

a—Ligula.
b—Labial palpus.
c—Mentum.
d—Palpiger.
e—Submentum.

Fig. 5.

Distal end of labial palpus showing tactile hairs.

Fig. 6.

Mandible.

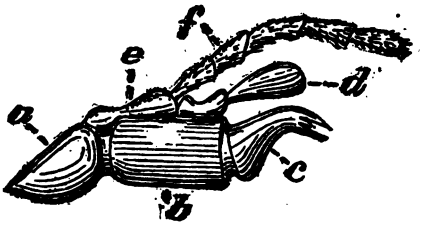


Fig. 8.

a—Cardo.
b—Stipes.
c—Lacinia.
d—Galea.
e—Palifer.
f—Maxillary palpus.

Fig. 9.

Distal segment of maxillary palpus.

the front of the epicranium, with the other two ocelli. Each antennae stands about half way between the ocelli on this imaginary line. The depressions in which antennae stand are known as the antennary fossa (figure 3). Joined to the epicranium, just below the antennary fossa, is the sclerite clypeus. To the clypeus is hinged the upper lip or labrum (figure 3). When the labrum is removed a pair of jaws known as the mandibles are seen (figure 6). These are notched at the distal end and so appear to have teeth. They are used for biting. Remove the mandible and a second pair of jaws, known as maxillae, will appear. (See figures 8 and 9 for the complicated parts of the maxillae.) Next to the maxillae is the complicated labium (figure 4). The labium or lower lip consists of the crescent-shaped submentum which is joined to the membrane connecting the head and the thorax. Hinged to the submentum is the mentum, which is the main part of the lower lip. On each side of the mentum is a sclerite, the palpiger, to which is joined an organ known as the labial palpus. There are two of these and each is three-jointed. (See figure 5.) The labium ends in two flaps known as the ligula. A tongue-like organ, the hypopharynx, appears to arise from the labium between the maxillae. Make a study of the maxillae and their palpi under the microscope, using three-fourths inch objective. Keep a live insect away from food for half a day, then put it on a blade of grass and watch the action of the mouth-parts.

The thorax of the grasshopper is made up of three rings or segments. These are named the prothorax, which is the ring next to the head; the meso-thorax, the middle ring; and the meta-thorax, next to the meso-thorax. To the thorax are appended the insect's legs and wings. A pair of legs arise from each segment of the thorax. A pair of wings arise out of the upper part of the second segment of the thorax, and a second pair out of the third segment of the thorax. These are respectively known as the meso-thoracic wings and the meta-thoracic

wings. See if you can count the number of sclerites in each ring of the thorax. In order to easily distinguish between the sclerites it may be necessary to boil the thorax in a solution of caustic potash. Examine the meso-thorax from below for two slit-like openings. These are known as breathing- spores or spiracles. Study the action of these in the live insect.

In order to examine the grasshopper's wings, place the specimen on the setting-board. With your forceps seize the outer wing and spread it out on the cork until it is at right-angles with the body. Fasten it with a strip of cardboard. Take the inner wing by its edge and spread it out. Pin it also in position. Notice how like a fan the inner wing is folded. The outer wing is somewhat thicker than the inner and is shaped like a blunt blade of grass. It is from this wing that the grasshopper received its name orthopter. This word means straight-wing. The name may further have been suggested by the manner in which the

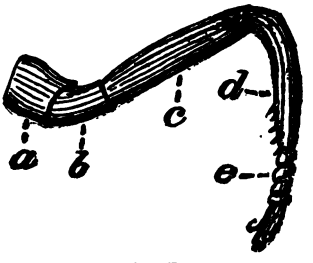


Fig. 7.

a—Coxa. *b*—Trochanter. *c*—Femur. *d*—Tibia. *e*—Tarsus.

wings are folded along the back when they are not used in flight.

Attention has already been called to the number of legs—six—which the grasshopper has. The term hexapod, which is the scientific name for insects, means six-footed. Insects are distinguished from all other ringed or jointed animals, articulates, by this simple foot-test. Each leg of the grasshopper has the following parts: There is a short segment, the coxa, nearest the

body; there is a second segment, much smaller than the first, the trochanter; the third segment is larger than the others; it is called femur; the fourth is the tibia—it is more slender than the femur; the balance of the leg, from the tibia, is the tarsus (figure 7).

We now come to the third division of the grasshopper's body; namely, the abdomen. A careful count of the segments in both male and female grasshopper will show eleven parts. (See Plate I.) There is a variety of opinion among entomologists as to which of the abdominal parts are true rings, the last two or three rings in the male and the last three or four in the female being considered by some as appendages of other segments.

In the first ring of the abdomen are two membranes, which are the hearing or auditory organs. In front of each ear, as we may call them, is a spiracle. Notice the position of other spiracles, as indicated in Plate I. Examine carefully the four strong, curved, pointed pieces which make up the ovipositor of the female. We will refer later to the use the insect makes of these in depositing her eggs in the ground. Trace out the caudal segments in the male, as shown in the plate, verifying each and every step by a reference to the specimen.

Take a large grasshopper, freshly killed. Remove the wings. Place the specimen back upwards on a soft piece of board; pin down the last abdominal segment. Turn each hind leg out and fasten or pin it down. Cut with your fine sharp-pointed scissors each side of the thin roof of the last ring; raise this up with the forceps; cut the roof of the next segment in a similar manner, also raising it up, and so continue to cut till the whole back is rolled off. The long tube you first see is the heart. It may cling to the back. Air tubes should appear on each side. A mass of yellow eggs will also be found in the anterior abdomen. Under the eggs look for the intestine. Next take off the roof of the thorax; look for the white muscles which move the wings. Under these muscles the digestive tube or intestine is continued.

In the first ring of the thorax is the gizzard; wash it and find the hooked teeth with which it is armed. A little farther back is the true stomach. The crop of the grasshopper is litle more than a tube in front of the gizzard, through which the food quickly passes. The white cord just above the floor or ventral view of the insect corresponds to the spinal cord in vertebrates. It consists of two distinct threads, the upper one smooth and containing no knots or ganglia; the lower one containing the ganglia in pairs. The ganglia send off nerves to the different organs; in the head the nerve cord sends around each side of the digestive tube a cord, which meet and form a ganglion analogous to the brain of higher animals, though it appears to be of little more use to insects than other ganglia.

Besides the insect's heart, nerve-cord, and digestive tract there is a complicated system of muscles and an intricate arrangement of breathing tubes which permeate every part of the insect's body.

As soon as she is grown, in late summer or early fall, the female grasshopper prepares to deposit her eggs in the ground. She does this by digging a hole by means of her ovipositor, the four prongs at the end of her abdomen. The prongs she uses as a drill, and with them she digs to the depth of about an inch. In the process she stretches her abdomen to its utmost length, holding the thighs of her large pair of hind legs close to her body.

The eggs are usually laid at three different times in three different masses. The species Spretus lays an average of twenty-eight in each mass. In other species the number varies from one hundred and twenty to one hundred and fifty in each egg-mass. The eggs are usually placed in a soil not too loose and with a southern exposure. It takes from four to six weeks for the eggs to hatch. The time varies according to the conditions of the soil, being lengthened by a situation in low, moist earth, or by a low temperature.

Though the eggs are generally placed in the ground, those of one species (Differentialis) have been found in large numbers under the bark of trees and under logs in moist ground. Another species (Stenobothrus) sometimes places her eggs in holes made in posts by the carpenter bee. Still another species (Chloealtis Conspersa) makes its egg-nest in dead wood. The eggs will always be found near or about cultivated areas, as the mother insect instinctively goes to these so that her young may have food.

When the insect has finished digging she fills up the bottom of the hole with a frothy, sticky fluid, and in it moistens her hard, bony ovipositor. This fluid exudes from the tip of the abdomen and comes from a gland known as the cement gland. When an egg has been placed in the nest it is covered with the fluid, which is usually called sebific matter. This hardens and thus holds the egg in place. The alternate process of moistening the horny ovipositor, filling the hole with sebific matter and placing the egg continues until the egg-mass is complete. The eggs are firmly held in place and protected by the sebific matter.

The eggs, far from being indiscriminately thrust into the hole, are carefully, regularly and economically arranged in four rows of about seven each. They are placed obliquely crosswise of the cylindrical hole, which is not solidly filled with the four layers, but the mother, guided by instinct of a most wonderful kind, in arranging her eggs leaves a channel of frothy mucus through which the young in the lowermost eggs can force themselves if by chance they are ready to leave the shell before those above them. The shell of the egg is double, the outer layer of shell being formed of sebific matter, the inner coat being the real shell. The latter is very tough, it being difficult to break, even with the fingers, when the egg is freshly laid. Before the egg is ready to hatch, however, the inner shell, from the effects of moisture or from other causes, has become somewhat decom-

posed, so that the baby grasshopper can easily break from it when the time of hatching comes.

When first hatched, while still within the hole, the baby grasshopper is covered with a loose skin or pellicle. This serves to protect the delicate limbs of the young insect from injury while it is emerging from the nest. It is cast off as soon as the insect is out of the ground.

The young grasshopper, nymph, as it is called, has an enormous appetite. It greedily eats of any fresh growth that comes in its way. As yet it has no wings and moves from place to place by hopping or walking. Soon its skin becomes so stretched from its rapid growth that a molt takes place; that is, it sheds its skin. A rapid increase in size of the nymph follows this change of skin, together with a corresponding increase in appetite. Later on a molt takes place which ends the insect's larval life, and it becomes a pupa. In this state it has a pair of wing-pads, which are but rudiments of wings, and mark the place of the true wings. The grasshopper in the pupa state continues its active life, unlike the pupae of butterflies and beetles. It is thus said that the life periods of the grasshopper, being three instead of four, are incomplete. Insects which pass through states corresponding with those of the grasshopper are said to have an incomplete metamorphosis. Finally, there comes a molt, after which the grasshopper is full-fledged and a perfect insect.

The full-grown grasshopper may be seen on any summer's day rising on wing against the wind, if there is any, and when at the height of from three to five feet allowing himself to drift with the course of the wind. When food is scarce grasshoppers have the habit of migrating in large numbers in search of more and better food. If the insects migrating are in the larval state they move by hopping and walking alternately. Half-grown grasshoppers are able to move in this latter way at the rate of from two to three yards per minute. They travel in no particular direction, but seem to move at random in search of food. Once started, the column does not easily change its course, but moves straight ahead over fences and brush. The head of the column determines the direction of the whole company. The whole line turns as the leaders turn, the word to turn being apparently passed down the line. The full-grown insect moves, when in

search of food, upon the wing. It rises when migrating to a considerable height and is carried to great distances in the direction of the wind.

Grasshoppers have numerous enemies, among them being a number of species of birds, which destroy myriads of them daily. The number destroyed by a family of larks in a single hour is quite astonishing. In the larval state the nymphs fall a prey to an ichneumon fly. The fly attaches its eggs to the back of the insect. When the eggs hatch the tiny larvae drill through the grasshopper's skin to the fatty parts. Here they feed until ready to pupate, when they drill their way out. I have several times found the larva of this cruel little fly when dissecting. I have also found in a grasshopper the larva of a tachina fly.

The familiar song or buzz of a grasshopper is made, in some species, by rubbing the large femur of the hind leg against the outer wing. The noise or stridulation is caused by the wing-cover passing over a row of spines upon the femur. In some species the song is made by rubbing the wing-covers against the upper edges of the second wings. The common cricket, which is also an orthopter, whose song is celebrated in poem and story, has an elaborate musical instrument. If you slip upon a cricket when he is singing you can easily see the mechanism of his fiddle. A light may be used at night, as the cricket does not appear to care for it.

One of the most interesting species of grasshopper to be found in California is the Angular-winged Katydid. It is at once recognized by its general resemblance to grasshoppers, its bright green color, its very long pair of hind or metathoracic legs, and its exceedingly fine, long antennae. The large, crescent-shaped ovipositor of the female is also a distinguishing mark.

The manner in which the Angular-winged Katydid places her eggs upon a plant is worth special notice. A soft leaf or blade is selected and first a slit or incision is made in the edge of the leaf. The slit runs lengthwise with the veining of the leaf. In this incision the egg is placed and completely concealed. I have several times seen this process of placing eggs by the Angular-wing. The plant used was a house umbrella plant, upon which I had placed the insect.

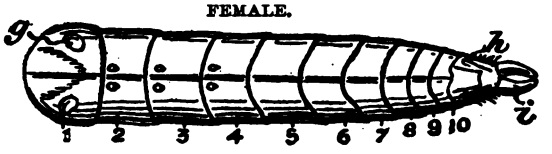
There are two broods during the summer season, but the eggs of the last brood are not hatched until the following sum-

mer. This insect is a voracious eater, and if present in large numbers would do much damage to foliage. It derives its name from the obtuse angle formed on the back by a rise in the wings from the head to the middle of the body, where appears the vertex of the angle, and from the middle by a descent to the extremity of the wings.

I wish to express my indebtedness to Mr. J. M. Stowell, Principal of the Hester School, Santa Clara County, for the original drawings from which the illustrations referring to the grasshopper were taken.—H. M. B.

DORSAL VIEW OF ABDOMEN. (Plate I.)

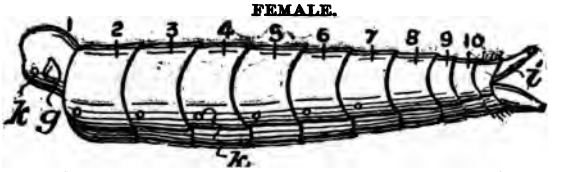
FEMALE.



g—Tympanum. *h*—Cercus. *i*—Part of Ovipositor.

LATERAL VIEW OF ABDOMEN.

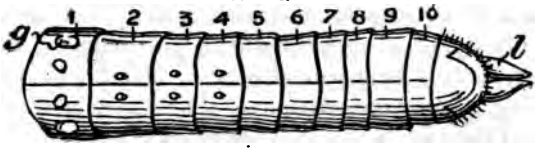
FEMALE.



g—Tympanum. *i*—Part of Ovipositor. *k*—Spiracle.

DORSAL VIEW OF ABDOMEN.

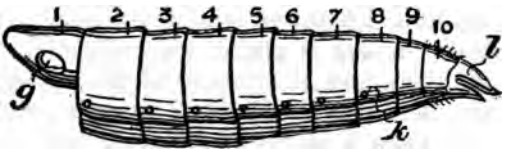
MALE.



g—Tympanum. *l*—Cercus.

LATERAL VIEW OF ABDOMEN.

MALE.



g—Tympanum. *k*—Spiracle. *l*—Cercus.

NOTE.—The eleventh abdominal ring in each segment is not numbered in above cuts.

III.

BUTTERFLIES AND MOTHS.

Butterflies and moths, because of their great beauty of color and of variety of form, have long been considered the most exquisite of insects. They may be recognized at once by the soft, downy fuzz, consisting of an infinite number of scales, which easily rub off from the wings. It is because of these scales that butterflies have been named lepidoptera (lep-i-dop'-ter-a). The scales of a butterfly should be examined under the microscope. This examination will reveal, instead of what appeared to the naked eye as fine fuzz, a most orderly arrangement of feather forms, each overlapping the other as if they had been fastened in place by the exquisite touch of a fairy carpenter.

The mouth-parts of the butterfly, as well as of the moth, while at first appearing very complicated, are really but a modification of the same mouth-parts that we found in the grasshopper. The long tube, used in sucking the juices of flowers, which you will find curled up under the head, is made up of the two maxillae fastened side by side. Other mouth-parts may sometimes be easily seen, but many times are obsolete, or partially so; that is, they have practically disappeared, because the butterfly has but little use for them. You will learn about the wonderful changes that a butterfly passes through during its life by reading the following story of the King of the Thistles.

Thistle King.

I first saw Thistle King as he was emerging from a green-colored, golden-dotted shell which was attached to our orchard fence. I watched him as his brown, crinkly wings straightened out into broad pinions. I petted him tenderly with my fore-finger, smoothing the brown hair of his back, a process which he seemed to enjoy; then watched him sail dreamily away to a cluster of thistles from whose flowers, with his long, black proboscis, he was soon sucking the sweets. It was then I christened him Thistle King. The name was appropriate, for during the few days I observed him the greater part of his living came from thistle flowers.

Thistle King had a very large bump of curiosity. A humming-bird perched upon a limb was sure to be closely inspected by him. He would hover a few seconds near the bird, eye it sharply, as if to say, "What kind of a fellow are you?" Again, the approach of another butterfly was the signal for a fluttering of wings and a contest of some kind in mid-air, perhaps in sport, perhaps a real fight.

Having marked Thistle King with a small notch in the wing, so that I could readily recognize him among his kindred insects, I watched him at intervals during four days, keeping a careful record of his habits. Sometimes he would soar into the air thirty or forty feet high; again, suddenly startled, he would wheel away in rapid flight. Now he would pause to drink from the calyx of a yellow borrage, or to sip from the blossom of a pear, or to vary his diet of thistle bloom with the thick juices of milkweed flowers.

On the fourth day of my observations I lost him, and though for some time after I kept a sharp lookout for him, I did not see him again. My experience with Thistle King so aroused my interest in him and his relatives that I at once decided to trace his entire life history. I believe now that if you were to

ask me to tell you about the butterfly whose life has the prettiest story, I am sure I would tell about Thistle King, who is known in entomologies as the Monarch.

The Monarch is one of our largest and best-known insects. It comes in earliest spring and flies all the summer long, leaving us only with the frosts of autumn. Its favorite resting-place at night is a tall Monterey cypress. In fact, I have heard it said that Monarch butterflies have been seen in swarms of thousands clinging to the leaves and twigs of this tree. When settled for the night it folds its wings straight over its back, just as all butterflies do, and, when thus resting, the sharpest eye is required to see it, as its deep brown color shades well into the dark green of the cypress leaves.

The largest of the Monarchs measures more than four inches from tip to tip, it being thus almost as large as the flaming Turnus butterfly, and quite as large as the richly-colored Camberwell Beauty or the lazy Anise butterfly. The brown wings of the Monarch have a black border or margin, in which, on both pairs of wings, there are two rows of white spots. On each side of the front wings, inside the double row of white spots, near the apex of the wing, are four other white spots. These are larger than those of the double row, but are also surrounded with black. The veining of the wings is black, but the black bordering of the wings in the female is broader than in the male, and near the center of each hind wing of the male there is a scent pouch attached to one of the veins.

The markings show from beneath the wings the same as those above. The body is jet black, but is marked with white dots on the head, on the thorax or chest just behind the head, and under the thorax. White, also, appears on either side of the abdomen, but not below or above. The antennae or feelers, when looked at under the microscope, show no scales. The absence of scales on the antennae is a mark of the sub-family of euploeids, to which the Monarch belongs.

The front pair of feet are so small as to render them useless, so that the Monarch appears at first glance to be four-footed instead of six-footed, as it really is. In fact, the Monarch belongs to the family known as four-footed butterflies, or nymphalidae. This is one of the four great families or divisions of butterflies. The other three divisions or families of butterflies are the Swallow-tails and Parnassians, represented in California by the Anise butterfly; the Gossamer-wings, represented by several species of blue butterflies, and the Pierids, represented by the Cabbage butterfly.

The mother Monarch deposits her eggs singly upon the milkweed. They are in shape of an ellipsoid having one end cut off or flattened, so as to be easily attached to the leaf. The egg is curiously fluted and presents in many ways a remarkable appearance. It soon hatches into a tiny caterpillar, which rapidly eats the milkweed leaves and seed pods.

While strolling one day near the banks of the Guadalupe, I noticed a large Monarch hovering over a cluster of milkweed. After a few graceful sweeps around the plant, then in full bloom, the butterfly lit, and began to feed with her long black proboscis upon the flowers. I had not watched her long before a second one appeared. This one, however, was not in search of food, but, as I afterwards found, placed an egg upon the leaf of the plant. This egg hatched into a caterpillar of striking appearance. I found several weeks later a number of the larvae which had hatched upon milkweed plants. These I took home with some of the plants. Putting the branches of the plant in a glass of water to keep them alive, and carefully placing the caterpillar on them, I put caterpillars, plants and glass under a large glass globe. Here my specimens were safe and ready for a series of observations.

After feeding for several weeks upon the softer parts of the milkweed, the eating ceased and one of the caterpillars began to crawl dreamily about the leaves and on the inside of the glass.

Then he wove a web on the glass in which he entangled his hind feet, swung himself up, and waited for the new life about to come to him. Soon the shape of his body began to change, becoming shortened and thickened. Then his caterpillar skin burst and there appeared a new creature of a greenish color dotted with yellow. This being, the new chrysalis, was still somewhat elongated, but it began at once to shorten into its permanent shape, the old rings of the caterpillar being folded in upon one another. The yellow dots now darkened into gold and the transformation was complete. The old caterpillar skin, with its useless tentacles, lay crumpled and black on the floor of the globe.

The appearance of the Monarch chrysalis is indeed rich and striking. The exquisite coloring settles finally into a delicate sea-green, running sometimes into a bluish tinge. The spine by which he hangs in his mysterious chrysalis sleep is jet black. This is surrounded by five line-markings in the shape of concentric rings, these being what is left of the rings of the caterpillar. A ring next to these is of burnished gold, dotted with black, making the gold appear by contrast more brilliant. All these markings were in the upper quarter of the chrysalis. On the balance of the chrysalis were what appeared to be eight golden nail-heads, so placed that one would think the chrysalis-skin draped together with fastenings of gold. Two golden dots also marked the lower extremity of the chrysalis.

It was in the fall that I made the observations which I have described so minutely. During the long winter my chrysalis remained quiescent. It was just such a chrysalis as Thistle King issued from, as I have described, while he hung to our orchard fence. Early in April, the following spring, the chrysalis-skin broke and the perfect Monarch emerged.

In common with several other of our butterflies and moths, the Monarch has a deadly enemy in the tachina fly. This insect, which is so useful in keeping in check the prune moth, attacks

also, and very cruelly, too, the caterpillar of the **Monarch.** As the lazy larva quietly feeds on the milkweed it is approached by the fly, which deftly places an egg on the back of the unsuspecting caterpillar, where the latter cannot remove it. When the egg hatches the young fly bores into the larval skin and feeds on the thick layers of fat beneath. It remains there till it is full-fed, when it leaves and turns into a small, brown, ellipsoidal chrysalis, from which comes the grown fly. Sometimes the Monarch caterpillar becomes a chrysalis before the tachina does. In this case the beautiful chrysalis shell of the former blackens before the latter emerges and in a few days a small, round hole shows where the tachina has come from. Usually, however, the Monarch has not the strength to change to a chrysalis, and ceases his eating only to die.

Some of the Monarch chrysalides, from eggs laid in early spring, hatch in the fall. Those formed in the fall do not change to the butterfly till the following spring.

The instinct of the newly hatched butterfly in straightening out its flabby wings is quite remarkable. As soon as emerged from the chrysalis shell the insect walks until it can grasp a limb, or side of the fence, with its claws. Here it clings and takes advantage of the force of gravity, which aids very much in drawing out the wing-wrinkles. Some of the larger species of butterflies, in fact, do not seem to be able to straighten out their wings without this aid of gravity, and if compelled to remain upon a level surface they become cripples instead of perfect insects.

This butterfly has an almost perfect double in a butterfly smaller in size, known very appropriately, from its resemblance to the Monarch, as the Viceroy. The cause of this resemblance has been traced by naturalists to the principle of natural selection. The Monarch is not a dainty morsel for birds to eat; on the contrary, he emits from his scent glands a very disagreeable odor, which renders him safe from the attack of birds. Now,

in a variable species, that is, a species in which there is a tendency to change, especially in color, those individuals of the species subject to attacks by birds and animals would have a better chance for preservation if they bore a resemblance to some insect which is refused as food. Thus the Viceroy, being a palatable food, has grown to more and more resemble the Monarch, all individuals tending to vary from the Monarch being destroyed. So that the Viceroy has in the course of the centuries gradually changed in color till at last only the experienced eye can detect the mimicry.

A close examination of the Monarch, however, will reveal a double row of white spots on the costal edge of the front wings; also a black band across each of the hind wings which appears in the Viceroy is wanting, while in the Viceroy there is no double row of white dots on the costal edge of the front wings, but merely two white spots on the edge near the apex of the wing.

About Our Common Butterflies.

We saw in the story of Thistle King that butterflies fall into four classes. These are Swallow-tails and Parnassians, the Gossamer-wings, the Four-footed butterflies and the Pierids.

One of our most common Swallow-tails is the Anise butterfly, otherwise known by entomologists as the Papilio Polyxenes (pa-pil-i-o pol-yx-e-nes). Sharp eyes will often find among the leaves of the anise plant a round, yellow egg, smaller than a pinhead. Sometimes one part of it is a little darkened. Sometimes the whole egg is dark. This is the egg of the Anise butterfly and has been stuck to the plant by the mother butterfly, who well knows how fond her sleepy young children are of the sweet juice of the anise. The yellow eggs are those just laid. As the eggs become older they grow dark, and when just ready to hatch are almost black.

When hatched the young one is a tiny caterpillar, black, with a light green stripe running around it near the middle of its

body. This green space gradually enlarges and becomes beautifully varied with black and yellow dots, so that when the young butterfly is ready to become a chrysalis it has become quite transformed and looks very little like the black worm that at first came from the egg.

The next time you find one of these caterpillars, touch him lightly with your finger; or, if you are a little squeamish about using your finger, use a stick, and you will find out how the little fellow defends himself. He will at length, if you persist in disturbing him, thrust out two V-shaped, fleshy yellow horns. From these comes an odor so disagreeable that you will be glad not to get your nose too near him. We can imagine the disgust of a saucy sparrow who had hastily popped one of these vile-smelling caterpillars into his mouth, thinking that he had found a pretty good morning meal. How useful this odor is to the young butterfly can be easily seen when we think what a fine mark his brilliant coloring makes of him for the birds. How different is the habit of this insect from that of the caterpillar of the Little Fox, which has such a dull color and which spins over the mallows leaf a net which draws the edges of the leaf together to protect him while he secretly munches parts of the very leaf he uses as a house.

When ready to become a chrysalis the young Polyxenes begins to give sudden jerks of the head sidewise. This seems to be to find out whether or not his caterpillar skin is ready to break, and can thus be easily discarded; for it must be remembered that when the caterpillar is ready for the third stage of its life the old caterpillar skin is thrown off or molted. The caterpillar now loses his appetite and at last leaves his old haunt on the anise and swings himself in some secluded corner or to a fence or outbuilding, where he sheds his skin and fastens himself partly by his hind feet and partly by a silken belt which passes around his body and holds him in a nearly horizontal position. In this position, if it is late in the fall, he remains all

winter. But if, when he pupates, it is early in the spring, he will probably come out a perfect insect in the warm, quiet days of early fall.

The Papilio Polyxenes is easily distinguished from its near relative, the Papilio Turnus, by a much larger amount of black upon its wings, the Papilio Turnus having the much larger proportion of yellow of the two. There is also a distinguishing mark upon each hind wing a yellow eye-spot with a black dot in its center. This is just in the angle of the Polyxenes' wing.

The Parnassius do not have the tail-like prolongation which Swallow-tails have upon their hind wings. Their wings have white as a general ground color. All, however, of this family of butterflies have the larval scent organs which we have described in the caterpillar of the Polyxenes. The Parnassians are rare in North America, being found, according to Comstock, on high mountains and in the far north.

Of the Pierids, there are a number of representative species in California. They fall into three groups, known as the Whites, the Orange-tips, and the Yellows. The caterpillars of these butterflies are usually covered with fine hairs. The chrysalides are swung up by the last pair of false legs and supported by a loose band around the middle. They may be recognized at once by a single projection, pointed, extending from the front. The legs of the imago are all fully developed.

On the afternoon of a warm autumn day, near College Park, I found six different species of butterflies, all fluttering around a few stocks of freshly blossoming lady teasel. The most conspicuous of these was the delicate little being known by the homely name, the Southern Cabbage Butterfly, a typical Pierid. So intent was this usually active flyer upon the honey cups of the teasel that I could have procured without great effort an unlimited number of specimens.

The Cabbage Butterfly has a record as a voracious destroyer of cabbages. The white, innocent-appearing, full-grown insect

does not do this, but in the larval state its natural food is the cabbage or mustard leaf. The caterpillar is a sixteen-legged greenish-blue worm, marked with from four to six yellow stripes, dotted with seven rows of black dots on each ring, and covered with dense hairs. It is about an inch and a quarter long. When ready to become a chrysalis it hangs by the hind legs and a transverse loop of silk thread passed around its body.

The eggs are yellowish, pear-shaped, with ribs extending lengthwise. They are laid three or four on a single leaf and hatch in a week or ten days. In a week the larva are full fed and become chrysalides, which last from ten to twelve days. The chrysalis is fastened to the cabbage leaf.

The Cabbage Butterfly has a most dangerous enemy with an enormous name, Microgaster Glomeratus, but withal quite a small insect compared with the butterfly it preys upon. Its wings are translucent, but when viewed through the microscope become wonderfully beautiful, giving off all the colors of the rainbow. The caterpillar is stung by the Microgaster, and through the cut made in the skin the latter deposits her egg, which, in due time, hatches into a tiny white grub. The skin of a caterpillar is sometimes found to be literally stuffed with these grubs, which, strange to say, do not eat the vital parts of their victim, but live on the fat which is between the skin and the vitals. This fat the caterpillar needs when he turns to a chrysalis, and on account of the lack of it he usually dies before the change is complete. It is said that out of a hundred caterpillars very few will be found without one or more of its deadly enemies.

While the Monarch butterfly, described in full in foregoing pages, belongs to the family of Four-footed Butterflies, the typical Four-footed Butterflies are the Nymphalids (Nym-phà-lids); unlike the Euploeids (Eu-ploé-ids), to which the Monarch belongs, the antennae of the Nymphalids are scaly, at least partially so. They are distinguished from the Meadow-browns or Satyrs by the fact that their front-wing veins are not swollen at

the base, this swelling of the veins being characteristic of the Meadow-browns. Again, they are easily distinguished from the Long-beaks, whose palpi are longer than their thorax. The palpi of the Nymphalid forms a beak, but one not so long as its thorax. They are finally distinguished from the Heliconians by the fact that the front wings are less than twice as long as broad. The fore wings of Heliconians are at least twice as long as broad. The foregoing statement of differences will serve to distinguish the five common groups of Four-footed Butterflies. These groups are the Heliconians, the Long-beaks, the Euploeids, the Nymphalids, the Meadow-browns.

The most interesting division or genus of the Nymphalids are the Angle-wings or Vanessids. These are so named because the outer margin of the front wings is notched or angled just as if a part had been cut away. Many Vanessids hibernate, and are the first to appear in early spring. Several species in California come from their hiding places on almost any warm, sunshiny winter day.

Among the most striking members of this remarkable group of butterflies is the Vanessa Atalanta (Van-es′-sa At-a-lan′-ta). It is called Atalanta because of its swiftness of flight. Atalanta, after whom the Butterfly was named, was a beautiful young woman, told about in Grecian fable. She was very swift of foot. She had said that the young man who would wed her must beat her in a foot race. If he ran with her and failed to win, he was to pay the forfeit with his life. Many young men loved her and undertook the race with her, but one by one they lost their lives. At last Hippomenes, who had acted as judge in the races, decided to contest. Knowing the difficulty of winning, he prayed to Venus, the goddess of love. The goddess answered him by giving him three golden apples. These he took with him when he ran, and when Atalanta was about to run ahead of him he dropped one, which Atalanta was so delighted with that she stopped to pick it up. Thus Hippomenes won the race and car-

ried off the prize. Anyone who has watched the butterfly Vanessa Atalanta dart about among orchard trees, its favorite haunt, will not doubt that it was appropriately named.

I had read J. G. Woods' beautiful description of this many-colored insect before I had the pleasure of seeing a single specimen in the field. The first one I did see was sucking the juices from fallen fruit upon a warm autumn day. The variety of coloring upon this insect is a marvel. On the hind wing, along the outer margin, is an orange-colored band. In this band is a row of black dots. On the upper part of the front wing, running from the middle of the costal edge almost to the angle formed by the outer and inner fore-wing margins, is also an orange band an eighth of an inch or more broad. This band is the insect's most prominent marking. Between the orange band and the wing tip are several white dots varying in size and shape. The under sides of the wings present a beautifully varied combination of white, orange and velvety brown, together with rare tints of delicate blue, with now and then a fleeting green. The antennae are tipped with white. The under part of the thorax is covered with long hair, and the abdomen, when the insect is quiet, fits into a cushion of soft brown hair, which grows on the inner margin of the hind wings. This striking variety of color is inlaid upon a background of black.

The Atalanta Caterpillar feeds upon the nettle. It makes a nest in a leaf much after the manner in which the Little Fox's nest is made in a mallows leaf; that is, it draws the edges of the leaf together and fastens them with silk. Unseen, it quietly feeds upon the tender parts of the leaf until it is ready to become a chrysalis. In the chrysalis state it is adorned with golden dots after the manner of the Monarch chrysalis and that of the Little Fox. The Atalanta shows a beautiful instinct in making a nest in which to undergo its transformations. Selecting a nettle stock of convenient size, it cuts with its sharp mandibles the stock nearly in two. This is done perhaps six

inches from the top of the plant. When nearly cut through the stock falls over, but remains hanging to the stump by the film of bark yet uncut. In the hollow cavity of the fallen portion the young Atalanta makes its pupal home, closing up the entrance with a web of silk.

Another curious member of the Vanessid group is the well-known Little Fox. The egg of this lively little butterfly is somewhat pear-shaped and about half the size of the head of a small insect pin. Its color is pale green. Under the microscope it looks as though it might be a delicious caramel, beautifully fluted as caramels sometimes are. This egg is glued to the upper surface of a green mallows leaf. When it hatches the tiny caterpillar crawls to that part where the leaf is joined to the stem. Here there is a little hole, or depression rather, and into this the larva crawls and spins over himself a protecting web. As he grows he spins more web, drawing the edges of the broad leaf together, to hide himself from any greedy bird or chicken, while he nibbles at the choice portions of the leaf. When ready to become a chrysalis the young Fox crawls to a fence or to the side of a house or shed and hangs himself up by his hind legs. To suspend himself he spins a web in which he entangles his hind feet. He now becomes a golden-dotted chrysalis, although the gold is somewhat faint.

It may be said here that the root of the word chrysalis means golden. I suppose the word was first exclusively applied to the golden dotted pupa of the Four-footed Butterflies, and then afterwards to the third life-stage of all butterflies.

The full-grown insect hibernates, but on warm, sunshiny winter Californian days comes out. It is one of the few butterflies that may be seen all winter. Another butterfly that hibernates, coming out as does the Fox on warm days, is the gorgeous Evanessa Antiopa, or the Camberwell Beauty. The Fox has the peculiar habit of returning almost to the very spot it flies from when it is disturbed. It likes the warmth and usually is found

on the sunny side of houses and outbuildings. It is by no means a wanderer, as it has been known to live within the bounds of a small lot for the whole summer long. The first of the Fox that I succeeded in colonizing near my home were brought from some distance in the chrysalis state. The young imagos seemed very well contented, and soon were raising families on the bunches of mallows on the warm, sunny side of the house.

All of the Angle-wings that I have examined have had, at the angles of each facet of the compound eye, a fine hair. These hairs serve to keep the numberless particles of dust which are always flying in the air from striking the delicate surface of the eye. In other words, the hairs form a protecting eyelash. We can see that this protection is especially valuable to Vanessids when we remember what rapid flyers they are and how much more likely their eyes are to be injured than those of the slower fliers.

The richly colored Evanessa Antiopa or Camberwell Beauty may be recognized by the broad band of yellow-white bordering the outer edges of its wings. The caterpillar is spiny and feeds upon the leaves of the willow or the poplar. I have seen the caterpillar congregated in large numbers upon the leaves of a single willow branch, which they nearly stripped of its leaves. It takes but a few weeks for the insect to pass from the larval to the pupal state.

The Meadow-browns have a representative in California in a small fawn-brown butterfly, about the size of the Vanessa Atalanta. It may be recognized by two terra-cotta spots, somewhat rectangular in shape, near the costal edge of the front wing. There is also an eye-spot on each front wing. The central dot of each is white surrounded with black. Next to the black is a yellowish-brown narrow ring. There are two eye-spots on each hind wing, the hindermost one being much the smaller. The

swollen wing veins typical of the Meadow-browns may be clearly seen in this butterfly.

Moths.

Moths can be distinguished from butterflies very easily by the experienced eye. The beginner may be sure that his lepidopter is a moth when he finds in it all three of the following traits uniting in the specimen: Wings not held vertically above thorax when at rest; antennae without clubs or knobs, except in very rare cases; activity at night. Generally speaking, moths have a much stouter and thicker body than do butterflies. Compare a miller, which you can easily catch by taking a lamp outside on a summer's evening, with a buterfly in order to fix the foregoing points in the mind.

The life, habits, and structure of a moth can be best traced in the large insect called the Prune Moth. The cocoon of this moth may be found in fall and winter clinging to the limbs of the prune tree. The insects issue from the chrysalis as the warm weather comes on. They are, both in size and splendor, the peer of any of our California hexapods. Nor is the brilliancy of coloring in the Prune moth larva any less striking than that of the full-grown insect. This insect is sure to repay faithful study in the pleasure its beauty gives, if in nothing else.

In the case of the hairy caterpillars of moths which weave a cocoon out of the hair of their bodies it would be well to force one of them to build a cocoon after having clipped off the hair, as then the change inside the cocoon may be observed through the thin covering. The result may be brought about by compelling the Caterpillar to make a new cocoon after he has used up most of the hair on the first he has attempted to make.

The Codlin Moth.

The Codlin Moth is one of the most troublesome insects in the apple orchard. Its presence may be readily guessed, as a tree troubled with it invariably drops its fruit before the apples are

ripe. Secure some of the apples and cut one or two of them open. Some have been tunneled out by a little animal which has disappeared; in others not yet fallen, you will find a worm-like animal which answers the description of a caterpillar. Its body is light, having not yet been exposed to light. Its head is light. Along its back you can see a stream of light-colored blood pulsating to and fro. The little vessel which contains the blood is the insect's heart. This is a mere tube running the entire length of the body. The blood always pulsates toward the head, the heart having valves which prevent any backward flow.

All insects have this kind of heart situated just under the back.

Watch some of the apples on the tree, and perhaps you may find a caterpillar leaving one to come to the ground. Possibly you may find one lowering itself by a silken thread spun by some spinnerets after the manner of a spider's thread. When it strikes the ground it goes at once towards the trunk of the tree, where, if it finds no suitable place before it gets there, it spins in a crevice under the bark a cocoon and goes into the pupa state. If in dropping from the apple it should strike a limb, it will crawl down that till it finds a place to hide and pupate.

Wrap some sacks around a tree, leaving the lower edge free a few inches above the ground, and tying the upper edge. As the caterpillar, after reaching the ground, crawls up the tree, it will hide here and may be easily caught. It is now of a pinkish color, which is the result of exposure to light. Caterpillars may be killed in large numbers by means of sacks wrapped around trees; but those which do not fall to the ground escape, as also do those which pupate in the ground. Once hidden the caterpillar weaves from its spinneret a silken cocoon; this is lined with silk and washed with a sticky fluid which makes it waterproof. In twenty-four hours the cocoon is complete. Here it stays during the winter, (although those which become chrysalides in early summer may be full grown in the fall) com-

ing forth a perfect insect the next spring, when it is known as the Codlin Moth, and is ready to deposit its eggs on young apples, pears, or quinces. Capture some of the caterpillars, place them in pasteboard boxes and raise some of the moths. Notice that, when grown, each has the characteristic roofed wings and clubbed antennae of moths; at least the antennae are not knobbed. Under a good glass the insect will be found to be richly colored. The upper wings are an exquisite dark brown, which deepens at the base and tip. There is a golden, oval-shaped mark at the tip of the wings which in certain lights appears crimson while a golden shade pervades the entire wing; at other times the wings appear as the most beautiful satin and at others the ordinary colors of gray and brown or black. The insect is active about daylight, when it may be observed sticking its eggs in the flower end of apples, that being the only portion of the young apple into which the newly-hatched Codlin can bore. If the egg, which is almost invisible, is not destroyed by a parasite (which is said to be the smallest true insect existing) it hatches in eight or nine days and at once penetrates the apples, boring first so as not to injure the core. Later on in the season the moth may place its eggs on the soft parts of ripening apples.

In twenty days after hatching, having bored downward through the apple till a hole is made large enough to discharge its chips and give it air, the first one being too small for these purposes, it has burrowed to the core. It is now full-grown and commences to bore out from the apple in any direction. It drops by a thread to the ground and seeks its place to pupate.

The sacks, heretofore described to capture the moth, should be supplemented with sacks placed in the crotches of the tree. Examine the sacks at least once in seven days, and kill all pupae and worms by scalding or otherwise. The sacks should be put on not later than the tenth of May.

Scrape the trees, using a triangularly shaped hoe with one side ground convex and the other two concave, so as to fit the tree. Sharpen a corner, between the concave sides, so that it may be used in the interstices of the tree. Place a cloth under the tree so as to collect the scrapings and burn them. In the destruction of all the young lies your success. Fallen apples are readily eaten by hogs or sheep, but the latter must be well watered to keep them from chewing the bark from the trees. All young in fallen apples must be destroyed.

The beautiful Tineans, the smallest of lepidopters, eat winding passages through substances upon which they feed. The fragments of the cloths which they sometimes eat are fastened together by silken threads spun by the insect itself. The cases thus formed cover the insect. Their eggs are lain in fur, woolen goods and in any cloth in which the fibers are of animal origin, sometimes but rarely in cotton. After fifteen days the egg hatches and the larva at once begins to gnaw whatever is near it, making out of the gnawing its silken lined coverings, which are shaped like cylinders. In autumn it becomes torpid; in spring it pupates and in twenty days is grown.

Turpentine placed on a cloth and put in trunks and drawers will kill them.

Fumigate with tobacco, sulphur or buhach. Tobacco placed in drawers will drive them away.

If a hot iron be used on the edges of a carpet, a wet strip of cloth having previously been laid down, the steam thus formed will be forced between the carpet threads and the moths will be killed.

Corrosive sublimate placed in the cracks of clothes-chests will repel the pests, as also will cayenne pepper or Scotch snuff.

The larva is a pale sixteen-legged caterpillar, very easily injured. It drags its protecting covering along with it, cutting whatever hairs may be in its way. The full-grown insect is of a

light buff color. Its long and narrow wings are bordered with a delicate fringe of silken hair.

There is a little Tinean known as the Peach-twig Borer, which is making itself a nuisance to the peach growers of California. The eggs of this moth are usually placed a little above the petiole of every leaf. At first they are white, but when about to hatch turn to an orange. They are ovoid in shape and are glued lengthwise to the twig. When the egg hatches the caterpillar bores into the bark, leaving by the hole in which he enters a little mass of brown excrement. If the young is hatched in the fall he makes a silk-lined cavity in the bark, and in this passes the winter, growing very slowly. In the spring he leaves his winter nest and burrows into the newly growing shoots. He now eats voraciously and grows rapidly. After burrowing in a shoot from a quarter of an inch to one and one-half inches he leaves it and repeats the operation of burrowing in a second. Thus before he is grown several shoots may be injured or destroyed.

When ready to pupate he spins a thin cocoon in the dried leaves of injured twigs, and in seven or eight days, if the weather is warm, emerges a perfect moth. The adult is a beautiful insect, being of a dark gray color. When at rest it bends its palpi back over its head and brings its antennae down close on its wings. It is small, being less than one-fourth of an inch long, and is so nearly colored like the bark that it is difficult to find. When at rest the front part of the body is slightly raised, and when disturbed the insect flies rapidly, but soon alights again.

The caterpillar reaches the length of half an inch. It is largest in the middle, tapering towards its head and tail. The head is brown, almost black, as is also the shield at the tail and the covering extending from the head over the first segment. The general color is dull reddish-brown. In searching for the eggs or for the burrows of the caterpillar, a hand lens will be found to be very useful.

There are several broods during the year. The eggs of the fall brood, which is the hibernating brood, are supposed to be laid in the crotches of the larger twigs. A kerosene emulsion, described in full in "Farmers' Bulletin No. 80," is the best remedy* for the pest. Other remedies are also discussed in this same number.

Near the close of summer there will be found near the roots of peach trees, sometimes just below the larger branches, bunches of eggs, stuck to the bark and arranged like the tiles in a pavement. These are the eggs of the Peach-tree Borer. When these hatch, the young Borer drills into the tree, then downward through the bark and sapwood till the following spring, when it forms a cocoon of chips, mixed with the peculiar gum which indicates its presence. By July the perfect insects issue. The larva, when full-fed, is from half to two-thirds of an inch long, of a pale yellow, and has the characteristic legs of caterpillars. Its head is reddish, marked with black. The imago is steel blue, marked with yellow, and resembles a wasp.

It infests that tree near the surface of the ground and when in any great numbers it makes an attack the tree is almost certain to die. To find this pest, remove the soil from the roots to the depth of four or five inches. Any moisture or exudation of gum found indicates the presence of the Borers. Probe the wound with a slim, flexible wire, or, if the tree is not small, cut the larva out, and cover the wound made by cutting with grafting wax or rubber paint; then cover with sand. This process will preserve the wood until the growth of new bark.

Heaping earth around the roots will not entirely prevent the attacks of this insect, but if this is done the earth should be removed as soon as the rains set in. A sure preventive is the following method. Remove two or three inches of earth in depth

* The proportions used in this remedy are: Kerosene, two gallons; whale-oil soap, half a pound; water, one gallon. Spray during December or January.

from the tree. Wrap the trunk with a piece of galvanized wire netting such as is used as window screens. Put the earth over the lower part of the wire and tie the upper part. This will effectually keep the pest from the tree.

If a Borer should be removed, cover the wound with grafting wax or common laundry soap.

Masses of gum always indicate the presence of the pest.

IV.

THE BEETLE.

The characteristic structure of Beetles may be gleaned by a study of the Triangular Water Beetle. This insect is a night-flier, but is found and easily caught under electric lights. It is large, being from an inch and a quarter to an inch and a half long, so that all the parts can be readily recognized. If you can procure one of these beetles, trace out parts of its body analogous to parts described heretofore in the grasshopper. If it can not be procured, a substitute for it may be easily found by overturning a few logs or stones.

Beetles are at once recognized by a thickened pair of horny wings covering or shielding a second pair of wings. The first pair are not really used in flight. The second pair are especially adapted to flight. The first ring of the thorax is very large and is "often excavated in front to receive the head." The compound eyes are large. Of the simple eyes there are at most but two, or there may be one or none. The antennae are of many forms. They are usually placed one in front of each compound eye. The mandibles are always large.

The characteristics of beetle larvae may be best studied in the broad-necked Prionus. This is best known as a large white grub, having a few projections from below which vaguely resemble feet. It is found boring in apple roots or in the dead limbs of apple trees. The cream-white larva has a pale blue line along its back. The head is black, and is armed with a strong pair of mandibles. These are used in boring. The thirteen rings of the body are easily counted, and taper from the largest just back of the head to the small one at the tail. Is

there any natural reason why the segment just behind the head should be largest? It would seem, as the larva bores very slowly through the wood, that the parts which have the best chance to grow are those nearest the head, while those near the tail are continually cramped by a narrow hole. Thus the segments near the head are left free to grow while those towards the tail are prevented from growing. Perhaps the greater use of muscles in the thorax and head may be another reason why the front segments of the larva are larger than rear segments. It will be noticed that all the wood-boring larvae of beetles have a tendency to an enlargement of the head and thorax along with a tapering tail. I have noticed this peculiarity in a relative of the Hickory-tree Borer, which I found in the dead wood of a madrone-tree.

The Broad-necked Prionus remains a larva for three years, then leaving the wood, unlike other members of the family Prionidae, it digs a smooth cavity in the earth. Here it becomes a pupa, undergoes its transformations and in about three weeks emerges a perfect beetle. When fully grown the larva is about three inches in length. The adult beetle is brownish black in color and from an inch to an inch and three-quarters in length. Three protuberances or spines resembling teeth border each side of the thorax of the adult. This Beetle can be distinguished from the Tile-horned Prionus in having twelve joints only in each of its antennae, whereas the latter has from sixteen to nineteen joints.

The beetles of the entire family of Long-horns (Cerambycidae) have recurved, filiform antennae inserted below the eyes, just above the base of the mandibles. The eggs are placed by the tip of the abdomen, which is made extensile, in the crevices of the bark of the tree in which the young beetle is to make its home. The adult is naturally a lazy fellow and takes to the dark. It remains quiet during the day, and at night flies in search of food and its mate. The name Prionus is from the

Greek and means a sawyer; so the name is well suited to this beetle and its relatives.

The family of Lady-birds (Coccinellidae) have a special interest for us in that they are the deadly enemies of Plant-lice or Aphides. I have known a colony of these queer little beetles to strip an orchard of apple trees of the Woolly-Aphis in the course of a few weeks so that not one aphid remained, except those on the roots of the trees. The family is easily recognized by the hemispherical shape of the body of the insect. The antennae are short. The prevailing colors are red or yellow, dotted with black, or sometimes the background of coloring is black, which is dotted with red, as in the case of the Twice-stabbed Lady-bird. When they are quiet, or feigning death, as Lady-birds sometimes do, the whole outside covering becomes a shield, protecting and concealing from view not only the wings, but the feet and legs. The Twice-stabbed Lady-bird reminds one of a turtle when it is disturbed, instantly concealing its legs and drawing the head back in under the body. Lady-birds have the power of emitting from the joints of their legs a very disagreeable odor, which, Wood says, becomes almost unbearable at that season of the year when in England they feed in swarms upon the plant lice infesting the hop fields.

Lady-birds usually lay their long, yellow, oval eggs in patches among plant lice. These hatch into rather long, oval, soft-bodied, pointed-tailed larvae, which at once begin to eat the plant lice. The front wing of the larval thorax is the largest. Its body is beset with spines or tubercles and is often gaily colored. I have before me the larvae of a Lady-bird whose name I do not know. He is a hungry fellow, and is devouring plant lice on the fragment of an apple-tree root which I have just pulled up for him. When he goes into the pupa state he will hang himself by the tail to the bark, or possibly to the leaf, of an apple tree, his caterpillar skin cast off, but remaining loosely around him. This skin he will crawl out of and leave hang-

ing to the tree when he is full grown. In some other species the caterpillar skin is cast from the body except from the tail to which it hangs.

A good example of the family Coccinellidae may be seen in the Australian Lady-bird (Vedalia cardinalis). This was brought to California from Australia for the purpose of destroying the Cottony Cushion Scale. So thoroughly has it done its work that no vestige of the scale remains, and valuable orchards have been saved.

If by chance you should have a tree infested with the Cottony Cushion Scale, enclose one of its infected branches in a mosquito netting, allowing the branch of course to remain attached to the tree. Place inside the netting a number of the Australian Lady-birds. In a short time they will begin to deposit their eggs upon the under side of the egg-sacks of the scale. These hatch in a few days and at once begin to feed upon the Cottony Cushion eggs, tearing open the white egg-sacks. In the meantime the Beetle itself will begin its work devouring a few of the scale. The young larva of the Beetle can be easily distinguished from the young Scales by the long black antennae which the latter possess. The beetles will increase very rapidly and it will soon be found necessary to remove the net. This may be safely done, as the Lady-birds are easily attached to a home where the Cottony Cushion is found.

In seven or eight days the young beetle molts its skin. It does this by attaching the hind part of its body to some object and then tearing itself out of its skin. The molting process is repeated in two or three days and again in five or six days. In four or five days more it goes into the pupa state, attaching its hind parts to some object with its head down. In about seven days more it issues a perfect insect. Its whole life is about two months. The colors of the beetle are red and black, there being two crescent-shaped black spots on the wing cases near the head, a black but irregular streak down the crease between the

wing cases, and two other black spots near the ends of the wing cases. The length of the full-grown insect is .23 of an inch. The Australian Lady-bird subsists entirely upon the Cottony Cushion and when its food is gone the beetles pounce upon each other, the younger and weaker being destroyed.

The Twice-stabbed Lady-bird (Chilocorus Bivulnerus) is common in the orchards of Central California. Its head, thorax and wing cases are black, with the exception that a bright red spot is found on the center of each wing case. It is distinguished from Pilate's Lady-bird (Exochomus Pilatei, Mulsant) in that the under posterior part of the abdomen is reddish, Pilate's Lady-bird in this part being black. It should not be mistaken either for the Eyed Lady-Bird (Coccinella Oculata), the spots on the latter being yellow. Pilate's Lady-bird is the largest of the three.

When disturbed the Twice-stabbed Lady-bird at once shuts up, turtle-like, and "plays 'possum"; nor can any amount of teasing, unless he falls, make him use his wings to escape. Turn him on his back and he still feigns that he is not alive. But on watching him closely for a few seconds his feet will begin to move, suddenly his wing cases will open, and, presto! he is on his feet again.

V.

NEUROPTERA.

This insect, commonly known as the Golden Eye, belongs to a family of the order Neuroptera,* whose characteristics are large, broad wings, intricately laced with nets; long, delicate, many-jointed antennae; small head, and very beautiful eyes. The foot has five joints and the wings are folded by the side. So beautifully is the insect colored that there is not one particle of black or white upon it. The body is green; the wings vary from green to pink; the eyes shine like burnished gold and are composed of six-sided facets, laid like tiles and marked with extreme clearness. Under the microscope the eye is very convex and exhibits a remarkable combination of rich colors, varying from a rich green to an exquisite carmine. "In fact, the whole eye looks very much like a hemispherical brooch entirely covered with emeralds and rubies."—Wood.

The insect appears in the evening about sunset, when it may be seen flitting through the air and at which time the specimen I examined was easily caught. After death, however, the beautiful color, the golden luster of the eye, is gone, the delicate pale green of the body departs and but little is left of the once magnificent beauty.

Lace-wings live by prey, feeding mostly on Aphides, but if two young Lace-wings meet a fight follows and the weakest is killed and eaten. They are extremely voracious and if supplied

*Neuroptera are four-winged, and the wings have numerous cross-veins. There is no beak, and the mouth parts are formed for biting. They differ from Dragon-flies in having a complete metamorphosis. The two insects described in this chapter are typical of two important families of the order, the Golden Eyes and the Ant-lions.

goes his pupal transformations. In a month he comes out a beautiful full-grown, fairy-like insect with exquisite, long, gauzy wings. On any hot summer day he may be seen flying about the banks of rivulets and in the warm nooks protected by hedge-rows.

VI.

FLIES.

The flies (Diptera) have but two wings, the second pair being replaced by a pair of knobbed threads, the use of which is not well understood. The wings are very thin membranes and either without hairs or with hairs so small that the microscope is needed to see them. The knobs, which take the place of the hind wings, can be easily seen on the crane-fly, or a careful examination of the house-fly, without a lens, will reveal them.

The so-called proboscis of a typical fly is made up of a sheath enclosing six bristles or lance-like organs. A study of the proboscis of a typical fly, under a lens, will reveal the six bristles enclosed in a sheath. The sheath is supposed to correspond to the lower lip of the grasshopper, while the six bristles, or lances, represent the upper lip, the tongue, the pair of mandibles, and the pair of maxillae. The lower lip palpi of the house-fly are large, being shaped like plates and used for rasping.

The metamorphosis of flies is complete. The larvae, known as maggots, have no feet usually, and are cylindrical in shape. There is sometimes a cocoon spun in which the third state is passed, but in most cases the pupa is naked or enclosed in the old larval skin.

Flies fall into two sub-orders; namely, the straight-seamed flies, so named because the pupa escapes from the larval skin through a T-shaped opening formed by a lengthwise split on the back near the head, and a crosswise split at the front end of the first split; and second, the circular-seamed flies—flies in which the pupa escapes through a circular hole made by pushing the head end of the larval skin off.

Flies are among the insects which are the most troublesome and at the same time most useful, considering how valuable some species are in acting as scavengers, devouring all sorts of decaying matter. We all have felt the vicious little thrusts from the lances of gnats and mosquitoes; on the other hand, the tachina-fly is invaluable to the farmer and gardener in that the larva is the deadly enemy of many a troublesome caterpillar, while an industrious grub of a syrphus-fly will, in a short time, strip a rose leaf of its most deadly enemy, the aphid.

Then there are flesh-flies, which infest our food, bot-flies, that torment our horses and cattle, and gall-gnats, which attack our crops. Then there is the clumsy crane-fly, which someone has imagined as singing:

"My six long legs, all here and there,
Oppress my bosom with despair."

In fact, among Diptera we have such an infinite variety of life forms, all with such varying and interesting habits, that a book a hundred times the size of this would not be large enough to tell about them all, even if they had been studied and written about. It is estimated that in America alone there are more than ten thousand different species or kinds of flies. Of these only about one-fourth have been described. In Europe there are about ten thousand known species.

The long-legged crane-fly, which is easily recognized by a V-shaped suture on the middle thorax, offers a good field of study for the beginner. The larva of some species are found under stones in water. I recently found two large specimens under a sheet of tin in the mud of the Guadalupe creek. At the posterior end of these were situated the breathing holes or spiracles, which appear as two eyes. Surrounding these were six tentacle-like projections. On the whole, the arrangement around the spiracles, together with the eye-like appearance of the spiracles, gives the larva quite a formidable appearance; indeed, so it must seem to

a water-beetle or to a tiny stickle-back which suddenly comes upon a young crane-fly. We shall find among insects many strange contrivances which, though harmless in themselves, serve to frighten away many a more powerful enemy.

The Horse Bot-fly is one of the most dreaded foes of horses. The female fly deposits her eggs on some part of the horse, attaching them to the hairs, with a sticky substance, in a place which the horse can reach with his tongue. When the horse bites himself he of course gets the eggs into his mouth and swallows them. Some are ground and destroyed by the teeth before they reach the stomach; those which do reach it safely hatch in a few days and by means of two hooks with which their heads are provided attach themselves to the walls of the stomach. Here they remain until fully grown when they pass through the intestines to the ground where they become pupae and in a few weeks are perfect insects. As an adult the bot-fly is very harmless, its mouth consisting of two or three little tubercles. The perfect insect is yellowish in color with red spots; the thorax has red or black bands. The two wings are crossed by a dark band and have red spots on the end of each. Wood says that he has seen a horse's stomach so completely lined with larvae as to almost conceal the inner surface from view. They remain in the horse's stomach through the winter, during which time they live on the juices of the stomach.

A horse having the bots does not eat heartily, becomes poor and appears to waste away. A well curried horse is seldom troubled, as currying removes the eggs. Slippery elm is recommended as a sure remedy for the bots. The elm is chopped fine and placed in the horse's grain.

The Ox Bot-fly deposits her eggs on the back of cattle, taking as much pains to put them out of reach of the animal's tongue as the Horse Bot-fly does to place its eggs in the way of the horse's tongue. When the maggot hatches, it burrows just beneath the skin, where a tumor is formed in which the maggot lives, its

head being downwards and its tail upwards. Upon the end of the tail are the two spiracles through which the maggot receives its air. The tail of the larva is thus easily seen protruding from the tumor. When ready to pupate it leaves its living home and falls to the ground, where it burrows a hole in which to undergo its transformations. In a few weeks it is a perfect insect. The adult is black and hairy, except on the thorax, which is banded with yellow and white. It produces a buzzing noise which cattle easily recognize, and which causes them to rush over the fields for escape. I have often extracted the ugly brownish black (sometimes whitish) larva from the back of cattle, which stand very quietly during the process, seeming to know that I was ridring them of their troublesome enemy. A heavy coating of any viscid substance, as thick grease, will close the openings of the tumor, and, of course, shut off the maggot's supply of air, causing it to die and fall to the ground.

The bumps on the California hare or jack-rabbit are caused by the larvae of a species of bot closely allied to the Ox Bot. Tumors are formed by the pest, the adult female making the same kind of an attack as does the Ox Bot upon the cow. I have cut the bumps open and found the larva but have not seen the perfect insect.

A near relative of the three preceding pests of this chapter is the Sheep Bot. This insect is supposed to be vivaparous and deposits its maggots in the nostrils of sheep. When so placed the maggots begin to crawl, moving upward until they reach the sinuses of the frontal bone. To these they attach themselves and hang till fully grown, when they loosen their hold and fall to the ground to pupate. The adult female is a dull ashy gray, the abdomen having black spots and being crossed by four black lines.

Sheep are greatly terrified on the approach of this insect and rush wildly from it or bury their noses in the dirt. When noticed holding their nostrils between their front legs close to

the ground they are endeavoring to escape from their dreaded enemy. Antelopes, the African gnu, and the deer are also subject to attacks from this insect or its relatives.

Mosquitoes.

The young of mosquitoes can be easily found at all times of the year. In any pool of stagnant water they flourish; even in an old rain barrel. They therefore can be easily studied by those who are interested in the smaller life forms, and are, when closely studied, found to be even more interesting than some of the larger insects. Any sluggish stream is sure to contain the larvae of mosquitoes. These, if taken home in some of their native water and placed in a glass fruit jar or in a beaker-glass, will surprise you by their curious life processes. A cover should be placed over your glass so that the full grown insects cannot fly away.

The youngest mosquitoes are known to all of us as "wiggle-tails." They are so named because of the wriggling motion they make in the process of swimming. If you watch a young mosquito wriggle you will at once see that the wriggling is only flaps of the tail, flaps quite enormous for so small a creature.

The eggs of the mosquito are placed by the mother insect upon the surface of a stagnant pool. They are glued together in form of an oval raft, the eggs standing on end and looking very much at first like a small particle of burnt leaf or paper floating on the water. From these eggs the wiggle-tails hatch and begin at once to eat the numerous little animals that abound in the water, most of them too small to be seen by the naked eye. It is necessary to keep your specimens well supplied with stagnant water, for that contains their food,and if it were replaced by fresh water they would probably die. Notice that when a wiggle-tail ceases to beat the water with his tail he slowly sinks to the bottom of the glass, unless he is at the surface of the water, then with his tail just at the surface he rests securely without sink-

ing, but he hangs head downward. The wiggle-tail is really an air-breather, and when he is thus quiet with his tail reaching to the surface of the water he is breathing. He takes the air into his body through a tube at the end of his tail; this can be plainly seen under the microscope. All the time he is breathing he is munching at such small life in the water as may happen to come within his reach. When he is really hungry though, he drops to the bottom and there his food is plenty. How does this little creature, which is really heavier than water, manage to hold himself to the surface? Simply by holding on to what is termed the water-film. What causes this water-film you will find out when you study physics. You can readily prove that a water-film does exist by wiping a very small needle dry and then placing it upon the surface of a pan of water. It will float, even if it is heavier than water. The water-film holds it up. Certain kinds of wasps are by the water-film enabled to stand on the water while they drink.

When ready to become a pupa the larval skin bursts on the back and a creature emerges that seems to be all head. The small tail that he has is very slender in comparison with his head. Nor does he eat as the other wiggle tail did, but he is much more quiet and contents himself with moving about much more lazily than did the other wiggle-tail, and instead of hanging from the surface by his tail when he breathes he hangs by his head instead. In fact his breathing tube is upon the back of his large round head.

In a short time the skin on the back again splits and this time a full-grown mosquito emerges.

The full-grown mosquito belongs to the two-wing flies and is a flesh-eater, living on the blood of mammals. The female is the huntress, as the male is harmless—eats nothing after it is full grown, resembling the male of some scale bugs in this respect and also certain kinds of May flies.

The bite of the mosquito is poisonous, as when it bites it injects, as is supposed, a fluid into the blood to thin it, since the blood is ordinarily too thick for the mosquito to take up through her sucker. It is this poisonous fluid that causes the swelling after we are bitten.

The mouth-parts of the full-grown mosquito vary greatly in shape from the mouth-parts of our type, the grasshopper. Yet all the mouth-parts are present. There is the upper lip, which has on it a pair of three-jointed palpi. The mandibles and maxillae are elongated into four bristles; these, with the long tongue of the mosquito, form a lance that the insect uses to pierce with when securing its only food, blood. The lance rests, when not in use, in a trough-like shield, which is supposed to be a modification of the lower lip. All these parts may be seen under the microscope and should be carefully looked up. The number of kinds of mosquitoes is indeed surprising. They live not only in warm regions, but are also plentiful in the colder Arctic lands.

VII.

THE STORY OF THE DRAGON-FLY.

"The sun on the hill forgot to die,
The lilies revived and the dragon-fly
Came back to dream on the river."
—Mrs. Browning.

Darning-needle is the name by which we know an imp-like little creature that one can see on any sunshiny day flying wherever there is water. The next time you go collecting catch several of these insects. You will know them by their long filmy wings, by the swiftness of their flight, by their ability to balance themselves hawk-like in mid-air or even to fly backwards when the occasion requires. Take several to your study. Look at the long body of one of the larger specimens. It really appears to have a long tail rather than a body. You can clearly see the ringlike segments of which it is composed. When the darning-needle dies and the soft parts of its body are gone, it easily breaks into rings, each being the shape of a hollow cylinder. At the central portion of the body, the thorax, the rings become irregular. The dragon-fly is a flashily dressed fellow, but very round shouldered, so that he reminds one of Quilp, the ugly man that Charles Dickens wrote about in "The Old Curiosity Shop." Yet his wings flash off colors as beautiful as those of the rainbow.

Like the grasshopper, the dragon-fly is a great eater, yet he feasts upon the flesh of other small insects instead of upon vegetable matter. He seems never to get enough. When one mosquito or gnat is eaten he is ready for another. Through the whole long summer's day he keeps up his chase and is as much

of a terror to small gnats and flies as hawks are to chickens or small birds.

Our well-known and Three-spotted dragon-fly may be taken as the type of this class of insects. It is so called because of the three dark clouds on the wing of the female. The male has a single broad band beyond the middle of the wing. This, together with a yellowish-red dragon-fly (Duplax Rubecundula), which is easily found in late summer or early fall, rests with wings extended at right angles from the body; and therefore both belong to the libellulas, which is one of the two great families of dragon-flies. The agrions, or second family of dragon-flies, fold their wings along the abdomen when at rest. The beautiful, blue, sylph-like Lestes Eurina is a member of this family.

The libellulas have a nearly rounded head, while the agrions have a head like a cylinder, and if the wings and legs of an agrion were off the balance of the body would look like a tack hammer. The Lestes darts around with such exceeding swiftness, that it seems but a flash of color as it passes in its endless chase after mosquitoes and gnats. Once in a while it lights to quietly feed on its victim, but is soon off again. These are three of the beings which we may expect to see on any of our warm summer days.

About as many stories are told of the dragon-fly as, in Salem two hundred years ago, were told of the witches. The little colored boy of the southern States will tell you that the dragon-fly has the power to bring dead snakes to life. The children of the north say that he will sew up your ears if he chances to find you asleep. These stories, of course, have no shadow of truth in them; yet the story of the dragon-fly's life is strange and interesting. The mother dragon-fly lays her eggs in the water, or fastens them to water plants, just beneath the surface of the water. She does this by lighting on the water plant and thrusting the end of her long body beneath the surface, attaches a

bunch of eggs to the leaf or stem. The eggs of some of the agrions are bright apple-green in color. Another dragon-fly (Libellula Auripennis) sometimes, it is said, drops her eggs in bunches while she balances herself a little above the surface of the water; at other times she will attach a bunch of a dozen of her yellow eggs to a reed just beneath the surface. As soon as hatched the young swim away in search of food, and hungry fellows they are, for they will attack anything alive that they think they can handle, from a mosquito wriggler to their dangerous enemy, the diving water beetle. They have strong legs and jaws and to the little pool, the insect water world in which they live, they are what the tiger is to the jungle.

The under lip of this savage little creature is greatly enlarged. The end of it is spoon-shaped and is armed with two sharp hooks for seizing and holding its prey. When the lip is not in use it is folded back and covers the lower part of the face like a mask; with the lip thus folded the insect loses all its savage appearance. The luckless insect who comes too near this fatal armour is suddenly seized and cruelly drawn to the mouth of its slayer, when it is leisurely eaten. With a pin this lower lip may be unfolded and examined. This monster of the brook, however, meets its match in the diving water beetle (of the family ditiscus) which generally comes out best in a fair contest.

As the young dragon-fly is a big eater he must shed his skin often so that he may have room to grow. Finally there comes a molt in which the larva becomes a pupa. In this state the insect still remains active, feeds about as much as before, and, indeed, looks very much as he did when he was a larva; but the wing-pads or places marking the future wings of the insect are larger and more clearly seen. When the insect molts, the skin first breaks along the back of the thorax; then, by fastening itself to some object at the bottom of the stream or pond, the skin is gradually thrown off. It may now have been in the water ten or eleven months, and one more month will complete its life. Just before being ready to change to the full-grown insect the pupa ceases to feed, climbs up a watercress or some other aquatic plant, and now once more sheds its skin, and the full-grown dragon-fly appears. At first it remains quiet and sleepy, its wings being soft and crumpled; then its skin hardens, its

wings straighten out, rich colors appear, and the insect seeks new life in a new world. Alfred Tennyson, in "The Two Voices," has thus described the final transformation of this mysterious demon-witch among insects:

> "To-day I saw the dragon-fly
> Come from the wells where he did lie.
> An inner impulse rent the veil
> Of his old husk: from head to tail
> Came out clear plates of sapphire mail.
> He dried his wings; like gauze they grew:
> Thro' crofts and pastures wet with dew
> A living flash of light he flew."

During the three or four weeks of his life in the air he is no less a destroyer of other insect life than he was when living in the water. Mosquitoes, gnats, and small flies are everywhere killed and eaten, and his enormous appetite seems never to be satisfied. We may even catch one with the hand, feed him with insects till he seems ready to burst, then turn him away only to watch him chase, capture and eat the first victim his great eyes light upon. While upon his raids for food, the dragon-fly's power of flight can be seen. Should he wish to make a quick turn, he can suddenly reverse the stroke of his wings, holding himself motionless in the air, or even moving backwards quite rapidly. This power of flight enables him to fly readily among obstacles or to back out of a narrow passage or corner into which he has flown.

The beauty and make-up of the dragon-fly is one of the most striking points of the insect. The wings are membranous and are finely netted. Near the front margin is a little notch at the end of a well-marked cross-vein called the nodus. The front wings equal the hind wings or are smaller, but never larger. When the insect is flying the flash of color from the powerful wings at once draws the eye, and the metallic gleams surround the airy being with a halo of splendor.

VIII.

HEMIPTERA.

There is a variety of the squash-bug that feeds upon milkweed, which is a good specimen to study, if one wishes to know the changes which hemiptera undergo. On a single plant I have seen this insect in every stage of its life, from the most minute form, just issuing from the egg, to the almost perfectly white specimen which has molted for the last time, leaving its dead skin hanging to a leaf or stem. After the final change of skin the insect gradually assumes the black and yellow colors which mark the adult.

This insect is a member of the hemiptera, an order which contains a large number of insect pests. The order has three subdivisions; namely, heteroptera, or true bugs, of which the squash-bug is an example; homoptera, or scale-bugs, aphids, leaf-hoppers, and others; and parasitica, or true lice.*

Homopters, heteropters, and parasites are distinguished one from another by the structure of the mouth-parts. If, for example, the snout of a squash-bug is examined with a lens, it will be found to consist of a jointed sheath containing four bristles. The four bristles are supposed to represent the two mandibles and the two maxillae. The upper lip is small and short, while the sheath which surrounds the bristles is supposed to represent the lower lip with its palpi soldered together. The beak or snout arises from the front part of the head. Homopters differ from heteropters in that the beak arises from under the back part of the head. Parasites have a beak similar to that of heteropters, but it is fleshly and not jointed. All three of the sub-orders above-spoken of have no biting mouth-parts, but live by sucking

*Birdlice differ from true lice in that their mouth parts are fitted for biting and not for sucking. They are wingless and do not pass through the pupa state. Bird-lice form a separate order of insects known as Mallophaga, since the earliest known insects related to bird-lice feed upon sheep's wool.

the juices or sap from the plants they infest or the blood from the animals they trouble.

Heteropters or true bugs have the first pair of wings thickened at the base, while the tips, which overlap each other, are thin and can be seen through. One should examine one of the giant waterbugs found under an electric light in order to understand the wing structure. In homopters the wings are of the same thickness throughout and usually the insect holds the wings in roof-shape at the sides of the body when it is at rest. This wing structure may be best studied in the cicada, an insect famous for its song, or rather hum. It is found in springtime upon the foliage of trees in the foothills.

The family of aphids is, perhaps, the oldest of homopters. It will repay one to take time to understand the habits of the family in detail.

If you should find an apple tree upon which the bark is rough, the branches gnarled and the wood dry and brittle, it is probably infested with the woolly aphis. The eggs of this pest are deposited in the crotches of the tree or upon newly grown shoots. They are covered with a light, cottony substance, and hatch in April.

In all stages of this insect's life it seems to be equally injurious to trees, sucking the sap; and when in large flocks they cover any portion of the bark, it seems to shrink and dry up under them. Ordinarily they have an excrescence of a white, cottony nature, which is easily rubbed off. They resemble ants, bees and wasps in that they have three genders, but whether the neuters are workers and aid in the support of the young, males and females, has not been determined. During the summer the young are produced alive, but in the fall eggs are laid which withstand the cold of winter and hatch in the following April.

The aphis is found not only on the branches and trunks of trees, but also on the roots, where their presence is shown by knotty excrescences. The white, wooly covering of the body is a sure sign of their presence upon the branches and trunk, where with their beaks they plow into the bark, withdrawing the sap, thus causing the leaves to turn yellow and fall. The woolly aphis yields no honey-dew, but often exudes from its abdomen a drop of sticky substance. Closely related to it, however, is the aphis which ants tend for the sake of the honey-dew it yields.

Ants capture droves of these, carefully taking care of them, feeding them on choice roots, but taking from them all the honey-dew they yield.

Lady-birds, syrphus-flies, lace-wings and some parasitic ichneumons are the natural enemies of aphides.

Some heteropters are very useful to the fruit-growers as enemies of plant lice and injurious caterpillars. The insect commonly known as the devil's wheelhorse is one of these. This predacious insect is found wherever there are scale or aphidae. The female deposits her eggs in hexagonal masses wherever she may happen to be, to the number of seventy. The young are blood-red, with black marks. Both young and adults prey on all kinds of insects, even their own kind. The adults are recognized by their gray color, the wheel-shaped appendage extending above the thorax and running parallel to the length of the body, and by the powerful beak or proboscis, with which it stabs its victim and into which it injects a powerful and deadly poison. It eats out the soft portions and drops the empty skin.

Scale-Insects.

The insects known as scale-bugs are, perhaps, of greater interest to the fruit-grower than any that can be named. This is because of their well-known destructive habits in the orchard and vineyard. They are so called because of their general resemblance to scales. These scales or coverings fit over the bodies of the insect and protect it, as the limpet shell does the animal beneath. Sometimes the covering is a part of the insect's body, and sometimes it is a separate covering, consisting of molted skins and secretions. In the second case the covering or scale is entirely free from the real insect that lives beneath.

Scales are either oval or circular in shape. They vary in size from the almost microscopic (Pernicious scale) to a quarter of an inch or more across, and they cling to the bark of trees as a barnacle clings to the bottom of a ship. They are flat in the earlier part of the adult state, but when the female becomes distended with eggs she is almost hemispherical or semi-ovoid in shape.

At present the most important group of coccidae for the fruit-raiser to consider is included in the sub-family diaspinae, or armored scales.

The young horny or armored scale (diaspine) in the larval state is oval in form, having the regular six legs, a pair of antennae, simple eyes, two bristles behind and a sucking apparatus in the middle of the membrane which fits next to the tree. The sucking apparatus is used in extracting the sap.

If a lens is brought to bear on a limb of an infected tree, the crawling larvae will be seen moving about in all directions. In a few hours after hatching the insect settles and attaches itself to some part of the plant, immediately inserting its sucker for nourishment. When once in, if taken out, the sucker can never be reinserted, as it curls up and is thus useless, the insect dying of starvation.

Having fastened itself to the tree, the insect begins to exude from its body a light, waxy covering which completely conceals it in a few days. This wears off and blows away in a short time, being at once replaced by a thin skin, which is tough, hard and horny. A small portion of the light, cottony mass which first appeared sometimes remains in the center of the scale as a ring or dot. In a few weeks the horny scale is completed, and the insect molts its first skin, which is, of course, fastened to the newly-formed scale. The molted skin strengthens the scale, forming its roof, while the insect is free but remains under the scale. With the first or larval skin are cast off the useless members; the joints of the body become mere fleshy folds. The insect has now degenerated into a mere mass of flesh, the only truly organized parts being the sucking apparatus or mouth, and the last abdominal ring or terminal joint, the legs, eyes, bristles and antennae being thrown off. The sucker now is developed into four thread-like bristles.

The last ring becomes flattened, and fringed with a large number of appendages, presenting under the microscope a beautiful appearance. It is composed of the very hard, almost indestructible substance, chitine, which renders the last segment almost as hard as a rock. Specimens are known to have been kept twenty-five years and yet to have the minutest parts perfectly preserved. There are several small holes through the upper or dorsal side of the segment through which the viscid substance is secreted to form the scale as the insect grows. The vaginal opening on the under side is surrounded by spinnerets, while

the posterior margin of the last joint is lined with appendages, the use of which, beyond the excretion of wax, is unknown.

As the diaspine grows the terminal ring is constantly exposed, but is rapidly covered again by the newly forming wax, and as the growth continues the entire outer edge receives thin laminae of wax. In fact, the growth of the scale is very similar to the growth of an oyster's shell. A short time after the first molt, a second takes places, the cast-off skin forming, as before, the roof of the scale and strengthening it. The females are now developed and begin to lay their eggs under the scale, beginning at the outer edge. The laying goes on until the female shrivels up and dies.

The male and the female larvae are indistinguishable; but at the second molting of the male the old skin is cast from under the scale instead of forming its roof, as in the female, and the male then goes into the pupa state, emerging after a week or longer as a perfect winged insect. It eats nothing during the adult period, being provided with no digestive apparatus. This is true at least of some species. In the life of the female the intervals between the molts are equal each to each, while the third interval in the male is shortened. The interval from egg-laying to hatching is equal to the preceding intervals combined.

Scale-bugs injure trees in several different ways. First, by sucking the sap; second, by shutting out the sunlight and air; third, certain species exude upon the bark of trees a honey dew which is supposed to be the cause of black smut; fourth, all poison the trees into which they insert their beaks—just as a mosquito poisons a person. The sap of a tree is ordinarily too thick to be sucked up by the scale, so it inserts a fluid beneath the bark to thin it. It is this fluid that poisons a tree, just as the fluid a mosquito inserts into the wound she makes poisons the blood. The Pernicious scale's bite turns the wood red just under the bark.

Examine closely a prune tree in a deserted orchard and you may find it has upon it minute scales. Pull some off and examine one with your lens. You will find in the center of the part which fits next to the tree a sucker. Examine the branch more closely with your lens. It is covered with numberless larvae. These are in all probability young diaspines. Put one

of these larvae under your microscope, and if you find two six-jointed or six-beaded antennae, that the insect is a yellowish color, two anal bristles, the body oval in form, and the regular six legs, you may be pretty sure that you have a pernicious scale* (Aspiodotus Perniciosus). This little pest feeds on all deciduous trees and is sometimes found on tomato vines and currant bushes when near infected trees.

The red scale belongs also to the sub-family of armored scales, and is usually found upon orange trees. The scale of this insect is almost transparent, but is a little mixed with gray, which is the color of the insect beneath. The insect's shape, as seen through the scale, is that of a kidney. The central third of the scale is darker than the outer two-thirds, and the portion of the insect covered by the outer two-thirds of the scale appears as a ring with about a sixth of the ring gone. This is the Red Scale; it may be always easily recognized by its kidney shape and its transparency. It is about one and a quarter lines in diameter. The yellowish spot in its center is the remains of the second cast-off larval skin.

The Cottony Cushion scale belongs to still a different sub-family of the coccidae. If in the course of your rambles you should find a tree upon whose branches are clusters of white scales, and if on closer examination you should find that these scales move freely, that they have six legs, that the head and body are covered with a mealy or powdery substance, that the yellowish-white portion is a soft, cottony bag, is an egg-sack containing oblong-ovate eggs of a pale red color, you have found the ravenous Cottony Cushion scale, which is a representative of the mealy-bug sub-family of scales, otherwise known by the long name of monophlebinae. The female before spinning her egg-sack is oval in form; her margin is bordered with spinnerets by means of which

* The following description of that delicately constructed little insect (Aphelinus Fuscipennis) is taken from a description by L. O. Howard This is a parasite of the pernicious scale.

Length of body, 0.06 mm.; expanse of wings, 1.3 mm.; greatest width of forewing, 0.2 mm. General color, dull honey yellow; antennae fuscous, almost black at tip; eyes blackish, ocelli dark crimson; a distinct transverse black band on the occiput behind the eyes; scutellum a little blackish at tip; abdomen with five dusky transverse lateral bands; legs and wing veins honey yellow; forewings with an indefinite fuscous patch below stigma, and another well defined, darker, somewhat crescent-like streak near the base, convex proximally.

she spins her egg-sack, which contains from two hundred to five hundred eggs—rarely seven hundred. The young scale (larva) is darkly reddish in color. Its antennae are six-jointed, with the last joint clubbed and larger than the rest. The legs are long and slender. The six anal bristles are long and prominent, standing on tubercles. When fully grown the antennae of the female become eleven-jointed; she begins to spin her yellowish-white egg-sack, becoming more and more sluggish. It is in this state that the Australian lady-bird takes particular delight in feeding upon this scale; and since the introduction of the beetle into this State the scale has been almost wholly destroyed.

The work of the Australian lady-bird in California is an example of what can be done in destroying insects harmful to vegetation by pitting against them insects which feed upon the harmful ones. An account of the Australian lady-bird is given in the chapter on beetles.

The genus Lecanium (sub-family Lecaniinae) of the family of coccidae is found everywhere that there is vegetation. They are sometimes called soft or waxy scales, because of texture of their skin or outer covering. In lecaniums, however, the scale is naked, and is a part of the insect. In this they differ distinctly from the armored scales, the scaly coverings of which are detached from the insect.

The growth of lecaniums from the egg to the adult is simple, there being no molts. Their eggs are deposited in a sack, beneath the body, or may be retained in the body till hatched. As they grow older they become sluggish, the limbs wither and adhere to the plant. They retain the power to remove and reinsert their beaks up to the time that egg-laying begins.

The black scale (Lecanium Olae) is one of the most common lecaniums in California. This scale is usually found in all olive orchards, and when its numbers increase is very destructive. It sometimes troubles citrus trees, but is more at home on the olive. Its color is dark brown or black and it is usually hemispherical in form, but may be a little longer than broad. On the back are two transverse ridges and one longitudinal, giving the appearance of the capital letter H. The edge of the scale is margined with ridges which extend half way up to the center of the back. The long antennae are eight-jointed, legs

long and not stout, and the anal ring bears six long hairs. The eggs are oval and yellowish in color. There is but one brood a year, and this is the most difficult to kill when on the olive. The larva is one seventy-fifth of an inch long. Its antennae are six-jointed. There is nothing peculiar in its appearance except the different colors it assumes before it is grown; namely, greenish-brown, reddish-brown and dark-brown.

The black scale, in common with its waxy relatives, retains the power to move until late in life. The honey-dew exuded by this insect causes black smut, which is a fungus that thrives and grows in the honey-dew.

An almost microscopic parasite female .08 of an inch long preys upon the black scale and keeps the pest in check. An accurate but scientific description of this parasite (Dilophogaster Californica) may be found in the Horticultural Report of 1889.

IX.

SOME MINOR ORDERS.

The May-flies, or Ephemiridae, as they are called because the full-grown insect lives but a short time, can be easily distinguished from other netted-winged orders by the shape of the wings. The front pair is very much larger than the second pair, and is very finely netted. Sometimes the second pair is wanting. The mouth-parts of the fully grown insect are undeveloped. May-flies eat nothing in the adult state. The abdomen is soft and long, and so transparent that the blood itself can be seen circulating within. The abdomen ends in two or three or more long, many-jointed, thread-like appendages.

The metamorphosis of this insect is incomplete; and the full-grown insect differs from all others in that its final molt is made after it has acquired wings for flight. The female deposits her eggs in the water in two long, yellow, cylindrical-shaped masses. each consisting of many eggs. She is said, in some species, to fold her wings about her like a diving-bell and to go to the bottom of the water to deposit her eggs upon stones or brush.

The nymphs live in water and feed upon small aquatic insects. They should be studied in an aquarium. They have long flat bodies, long hair-like antennae and small eyes, the ocelli being wanting. Their jaws are long and shaped like sickles. Along each side of the abdomen are bushy false gills. The abdomen ends in feathery appendages. The nymphs live two or three years, burrowing under stones or in the mud. The nymph of one species is known to pass through twenty-one molts before it is full-grown. Wing sacks begin to appear after the ninth molt.

The perfect insect is very frail and should be preserved in alcohol, as it soon shrivels when an attempt is made to mount it. Myriads of May-flies often appear in spring or summer and the pavements are made slippery with their dead bodies. I re-

member to have passed through swarms of them as they came from the sloughs in the tules of Yolo county, California. In wonderful contrast is the few hours of life of this dainty, trembling creature, when full-grown, with its twenty-four or thirty-six months of nymph life under the water.

Siphonaptera.

Fleas are insects having no true wings, but in their stead four scale attachments which are abortive wings. They are a type of the order siphonaptera, so called because of their tube-shaped mouth and because of the fact that they are wingless. They are covered with a hard, shining, horny skin, on which are rows of sharp bristles. When crawling through any tight place these bristles prevent any backward movement. Ordinarily fleas move by crawling, but when in danger they use their long, strong hind legs in making prodigious jumps. Their biting apparatus consists of the ordinary mouth-parts of insects modified to suit their use. Examine a flea under the microscope. Notice especially the mouth-parts. The female flea deposits from ten to twelve eggs in the cracks of the floor or in floor rugs. The larvae when hatched are tiny and white, having nothing to resemble legs but a series of hairs and two hooks near the tail, by means of which they propel themselves.

They have biting mouth-parts and live on decaying particles of animal and vegetable matter which they find in the cracks and crevices of floors. When the larva is full-fed it spins a cocoon in which to undergo its changes.

Fleas remain in the larval state during winter, pupating in the spring. They remain a pupae about a week, when they emerge as perfect fleas. Such is the life-history of the troublesome flea. Suffice it to say that it is one of the most interesting and the strangest of insects we have and will repay close study.

The best method of ridding a place of fleas is the thorough destruction of all rubbish and disinfection of all apartments with buhach.

Isoptera.

White ants are the most perfect type of this order. They are not really ants, as their metamorphosis is incomplete; nor are they even related to the true ant. They have come to be called ants because of their habit of living in colonies. In each

colony of white ants there are three classes. First, the workers, consisting of wingless females. These look somewhat like true ants, but their waists are much thicker. Their business is to procure food for the entire nest, and to nurse the young termites. Second, there are wingless soldiers of both sexes. These have very large heads and their jaws are powerful. There are, third, the kings and queens. These produce the young and are the real parents of the colony. They are winged and in the spring they leave the nests in swarms to start new colonies. After a short flight they drop their long wings, which are sometimes twice as long as their bodies. Soon mating begins, and each pair undertakes to start a nest. If by chance they find some workers, all is well and the nest grows; but if no workers are found the royal pair has but to die. If the nest is successfully started, the queen begins to develop eggs and her body grows enormously, sometimes to the length of six inches. She then looks more like a potato than anything else, and a casual observer might think that she had no relation to the myriads of termites in her nest. She is, of course, perfectly helpless, and would starve but for the faithful workers, who carefully feed and attend her. The king termite also, when she is in this helpless condition, remains true to her, while busy workers take the eggs as fast as they are laid away to other chambers of the nest, where they are hatched and attended. The young termites are much like the older termites in appearance. In case a nest loses its queen, males and females are developed in the nest. These are wingless and are not capable of producing nearly so many eggs as the real king and queen.

The worker termite of the African white ant, according to Drummond, is stone blind. All classes of this insect, it seems, avoid the light. Wherever they go they build covered passages of mud. They live on dead wood, and in many of the tropical countries become a pest, as no one can tell when a piece of wooden furniture, a fence or even a house, will be ruined and finally crumble to pieces as a result of their work. A piece of wood which they have eaten bears no outside evidence of their ravages until it suddenly crumbles to pieces, having become a mere shell. In Florida orange trees are killed by white ants, which girdle the trees beneath the surface of the ground.

Drummond, in "Tropical Africa," says that the white ant does for the tropics, in loosening the soil, what the earthworm does for the middle latitudes. It will be remembered that Darwin has shown how, in temperate countries, the myriads of earthworms, by constantly burrowing and throwing up to the surface the new earth, act as natural cultivators of the soil. In the hotter portions of the torrid zone, where earthworms do not work, the termite takes his place, and as he builds earthen galleries wherever he goes, even when he climbs to the top of a tree in search of his favorite food, which is dead wood, large amounts of soil are carried to the surface to be scattered to the winds when the galleries crumble, as they always do.

To what an extent the termites work in African forests can be seen when it is remembered that no dead and fallen limb of a tree is permitted to remain, but once on the ground is attacked by an army of termites, who soon destroy it completely.

An African forest has the appearance of having been swept and cleaned by industrious fairies, so thoroughly do the invisible termites do their work of cleaning away dead and fallen branches.

A relative of the termites makes its appearance from the earth in large swarms in California just after the first rains in autumn. It is not more than the eighth of an inch long, and its body is black in color. After a short flight it loses its wings and disappears. Another species is found in the Santa Cruz mountains, under stumps and rotten logs. I attempted to capture and keep for observation a family of these, but I was not successful in finding the queen, and the swarm died.

Thysanura.

These insects are thought to be the connecting link between hexapods and myriapods, since they have rudimentary legs upon the abdomen. Though they have no legs, they can jump very far or run very fast. They undergo no changes, the adult being of the same form as the young insect. The mouth-parts are retracted within the cavity of the head and are therefore difficult to see, as the lips only appear. The order is divided into two distinct sub-orders, one having a sucker on the ventral side of the abdomen, the other not. The first are known as bristle-tails, the second as spring-tails.

The fish-moth is a member of the first sub-order. It is abundant in warm climates and often damages wallpaper by eating out the paste. It destroys starched clothing, and book-bindings. Under the microscope it shows beautiful markings upon shining scales. It has three bristle-like appendages attached to the end of the abdomen; hence the name bristle-tail.

The second sub-order is known as the spring-tails, because of a tail-like organ that is bent under the insect when it is at rest. By suddenly straightening out this little organ the spring-tail is able to jump several feet. Spring-tails may be found at almost any time a year in damp places.

CARRODENTIA.

I have at home in the library an ancient volume which came to me an heirloom from my father. It bears the mystifying name "Theodicy." This book is interesting to me just now not only because of the source from which I got it, or because of the literature it contains, but because it is the home of a family of genuine book-lice. I open its musty leaves and the little, pale, wingless creatures scurry across its pages. Under the lens their black eyes may be easily seen, and the brightness of these makes one believe that they might do something more with the book than simply gnaw its time-worn pages. This insect, small as it is, bears the ponderous name Atropos Divinatorious.

Book-lice resemble aphides and may be easily mistaken for them, as there are both winged and wingless forms in the same species. In the winged specimens the veins are prominent and there are but few cross-veins. The fore-wings are the larger. Both pairs are folded roof-like over the body when not in use. The jaws are armed for biting. The metamorphosis is incomplete.

There is but one family, the Psocidae, in the United States. Some members of this are found in great numbers upon the bark of trees, where they may be easily mistaken for plant-lice. The eggs are laid in heaps upon the leaves of plants and held in position by a netting of threads spun by the parent in a manner similar to the spinning of thread by spiders.

The Divining Atropos, above referred to, is the litle pest which sometimes does so much injury to the insect specimens in our cabinets.

Scorpion-Flies.

These have four membranous, numerously-veined wings. The head is extended into a beak, at the end of which biting mouth-parts are situated. The metamorphosis is incomplete.

Scorpion-flies are found upon the banks of streams which are shaded and lined with rank weeds. The larvae resemble caterpillars very much, even possessing fleshy prolegs, but of these there are eight pairs, while caterpillars have generally but five pairs. The name scorpion-fly arises from the shape of the caudal part of the abdomen, which readily suggests the poisonous tail of a scorpion. The scorpion-fly's tail, however, is far from poisonous, and instead of ending in a sting, ends in a pair of clasping organs. The wings are longer than the body and in the species Panorpa are yellowish, spotted with brownish black.

The scorpion-fly undergoes the pupal changes in the earth and is buried sometimes an inch deep.

The Stone-Flies.

The stone-flies are insects which resemble the neuropters to a great extent, but differ from them in that the hind wings are folded in plaits and both pairs lie on the abdomen when the insect is at rest. The hind pair of wings is the largest. The metamorphosis is incomplete, and the mouth-parts, while of the biting type, are often poorly developed.

The larvae of this insect are found under stones in the water; they are flat and from one-half an inch to one and one-half inches in length. They are scarcely noticeable, so closely do they cling to a stone and so nearly are they the color of it. Two caudal bristles protrude and there are six white soft gills, one behind each leg. Stone-flies are a favorite food of brook trout. The nymph, when full-grown, crawls to the bank of the stream it inhabits, sheds its skin and becomes a fly of a grey or greenish color. The cast-off skins of stone-fly nymphs are seen on creek banks and are often mistaken for a live insect, in such perfect shape is the skin thrown off. The adult insect eats but little. The antennae consist of many joints and are long and tapering.

Physopoda.

Very small black or red insects are sometimes found in clover blossoms, at the base of the petals, when the latter are closely

examined. One of these little insects is not more than the twelfth of an inch long, yet when they are disturbed they point upward their minute bodies just as if they intended to sting. They are very active and leap or fly very quickly. When looked at closely with a lens, the four wings appear to be very beautiful, being fringed with delicate hairs. The red specimens are found to be wingless. They are the young of the black ones.

The wings are long and narrow, with but few veins and hardly ever any cross-veins. When at rest the wings "are laid horizontally along the back." The mouth-parts are most likely used for sucking, yet they have not reached the complete development of the mouth-parts usually found in sucking insects—the homopters or heteropters, for example. The mandibles are more like bristles. The flat maxillae are furnished with palpi. The legs do not end in claws, but in a bladder-like formation from which the name, physopoda, meaning bladder-footed, is derived. The metamorphosis is incomplete. Some species destroy useful grasses by working in the soft upper joints. Others live under the bark of trees. The Cereal Thrips is very injurious to wheat. Certain leaf-hoppers are sometimes called thrips, but are really homopters.

Trichoptera.

The little yellow caterpillar which lives in the rocky streams of Californian mountains, encasing itself in a tube made of leaves, grasses, bits of wood, or even sand, glued together, is well known to all trout fishermen. The case which protects this strange little fellow is closed except at the end at which the head appears. This opening the caterpillar guards with his black, menacing mandibles. Two strong hooks on the tail anchor the insect firmly in its tube. When moving it stretches its elastic body until the legs are far enough out of the tube to be used, when it slowly crawls over the rocks. When disturbed the head and legs are at once drawn into the protecting tube.

When ready to become a pupa the opening from which the head protrudes is closed up with a grating spun of silk. This net is said to be made in as many different ways as there are different species of the caddis, as it is called.

The grown caddis is swift of foot and can run with curious rapidity even over the water, leaving a long track in the water

behind it. Wood says it can even travel under water, crawling down some aquatic plant to attach its egg-masses under the water.

When under the water it often is a prey for fish.

Their egg-masses, which are double, the females carry with them for some time before the eggs are finally attached to some aquatic plant. The eggs once deposited, the female caddis becomes a mere shell and soon dies.

The full-grown insect has four wings. The first pair are covered with hair which is long on the chief veins of the caddis but short on others. The tibiae have long spurs. The adult insect takes no food, its mouth being undeveloped, like that of the May-fly.

An interesting note in the "Complete Angler," by Izaak Walton, tells how to bait a hook for trout with the caddis. See chapter XVII, Part 1, "Complete Angler," latter part of the chapter. However, I fear that Izaak Walton was not very humane in his treatment of the insects that he used for bait; not so humane, at least, as the great naturalist, Darwin, who very early in his fishing trips made it the rule not to impale live worms on his hooks.

When the pupal skin bursts the larger species of caddis crawl up some water-plant to dry their wings before flying away. Smaller species stand on the dead larval skin, as a sort of boat, while the wings are drying.

Caddis-flies are known to entomologists as trichoptera, or hairy-wings, from the dense coat of hairs on their front pair of wings.

The Order of Earwigs.

This order can be distinguished from all others by the peculiar manner in which the hind wings are folded. When the wing is not in use it is folded first in plaits like a fan, lengthwise. It is then folded twice cross-wise. The first pair of wings are leathery and resemble those of beetles. The earwig differs from the beetle, however, in that its metamorphosis is incomplete. The abdomen ends in a forceps-like appendage; the mouth parts are formed for biting. The scientific name of this order, euplexoptera, means "folded-wings."

There have been many points concerning earwigs about which entomologists have for a long time disputed. Some writers be-

lieve them to be a kind of beetle and so class them with coleoptera. This is because of the thick, leathery nature of the front pair of wings. The inaccuracy of this statement will be seen when we remember that a true beetle's front wing is horny, not leathery. Some think, on the other hand, that being related, though distantly, to the cockroach, they should be classed with grasshoppers. Comstock solves the problem of classifying by placing them in the separate order, euplexoptera. Again, those who find a great deal in a name are ready to quarrel over the origin of the word earwig. Some say that earwig was a name given to this little insect because of its supposed habit of crawling into people's ears while they are asleep. Others say the word is really earwing, the insect being so named because when the second wing is spread it resembles in shape the outer ear.

It is very difficult for an inexperienced naturalist to unfold, for mounting, the beautiful second pair of wings of the earwig. These, as has been said, are so intricately folded and tucked away under the heavy wing-covers that it is wellnigh impossible to straighten them out for setting. And if one succeeds they are so rubbery that they can scarcely be kept in place. From the difficulty of unfolding the earwig's wings, it may be imagined that the process by which the insect itself folds and tucks them away is very interesting. The forceps on the tail come in for use in this process. First, the wings seem to fall into a mass of wrinkles without any evident order; then the abdomen, with the forceps, is bent back, and by use of the latter the pliable wings are securely stowed away.

The earwig mother places her eggs in a damp, moist place and watches them carefully till they hatch. If any of the conditions necessary for hatching are removed, the mother will quickly remove the eggs to another place. Even if the eggs become for any reason scattered, she will carefully collect them again. When the young hatch, the mother broods her young just as a hen does her chickens. It is said that there is no other mother among insects which cares for her young in this way. The queen ant, or bee, or termite, do not pay any attention to their offspring after the eggs are deposited, the young being attended to by the workers. In fact, the young are so many among ants and bees that the queen mother could not take care of them.

The young earwig looks very much like the old, except that the forceps are not so developed and are not so well curved. Nor are the wings perfect till the insect is full grown. The perfect insect has fourteen joints in its antennae, while the nymph has but eight.

Earwigs are active at night. They eat both animal and vegetable food, preferring, though, the latter, as they are especially fond of the dahlia and the carnation. These they ruin by nibbling off the edges of the petals. Earwigs may be captured in large numbers by placing cans or shells or any material in which there may be holes in which the insects may hide, about or upon the supports of the plants they infest. This method of capturing is often employed by gardeners.

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X.

THE MEMBRANE WINGS.

Ants, Bees, and Wasps.

Hymenoptera have four membranous wings, with few cross-veins, the hind pair being the smaller. The females have on the tip of the abdomen a sting or piercer, or a saw. The mouth is furnished both with mandibles and with a sucking or lapping apparatus. The insect passes through the typical four stages of development; viz., the egg, the larva, the pupa, and the imago. The following pages deal with bees, ants, and wasps. The literal meaning of the word hymenoptera is membrane-wing.

A colony of ants may be kept in captivity in a nest made as follows: Take two panes of thin window-glass, each about ten inches square, place one on the other, separating the two such a distance as will just allow the ant which you wish to capture to walk between. Do not get the distance too great. Put strips of wood around the edges between the two to hold the panes in place. Leave the strip of wood on one side loose. Fill the space between the panes with fine damp mold, and place the whole in a shallow, tight box. Cover the box with glass, putting a strip of baize between the glass and the wood. The baize will not allow the ants to escape, yet it will allow sufficient air to pass through to keep them alive and healthy.

Dig up a nest of ants, taking the earth with it, so as to disturb as little as possible the nest and its contents. Place the lump of earth containing the nest in the box upon the glass nest which you have prepared, and put on the glass cover. As the lump of earth dries remove it little by little. Soon the ants will leave it and tunnel out a new nest between the panes of glass. They will carry into the new nest all their stores and their young—the eggs, the larvae, and the pupae. Soon the old nest may be all removed, leaving them in possesion of the new one. The process of removing from one nest to another will take about a

week. As ants like the darkness, it will be necessary to keep the glass nest covered with fine sand. This may be removed when you wish to make observations. It is necessary to keep the glass nest damp by supplying a little artificial rain.

Your myriad of pets may be fed upon sugar, together with small insects or bits of meat, of which they are especially fond. Some species will also feed upon grains.

Instead of putting the glass nest in a box it may be surrounded by a moat of water. Over this the more tamable species will not cross. I did not succeed, however, in confining the familiar but ferocious little ant that can be found foraging on almost any summer's day on our stone sidewalks. This species would dash wildly into the water, and no amount of coaxing could prevent it from so doing. The box arrangement proved better for these ants.

I succeeded best in taming a nest of very small black ants that were easily controlled by the water moat and were easily coaxed into the glass nest. I discovered these about the roots of a pear tree. Several individuals were running about among a colony of brown-colored aphides. The nest was in a lump of earth, about the size of a hat, at the foot of the tree. I was able to observe in this family much of the life-history of ants.

The metamorphosis of the ant is complete; that is, the egg hatches into a larva, the larva changes to a pupa, the pupa in time becomes a full-grown insect. The eggs, larvae, and pupae are carefully tended by the younger workers, since the younger workers are not strong enough to undertake the more difficult work of foraging for the family. The undeveloped ant is tenderly carried about by his nurses, who move him from one place to another in the nest to keep him as near as possible in the same degree of heat. When an ant comes out of the pupae state his wings and legs are carefully unfolded by his nurses; in fact, the young of the ant are not able, alone, to straighten themselves out after coming from the pupae. The larvae are grubs, small, white, legless. They are usually kept in groups, those of the same age being together. It takes from three to six weeks for the larvae to become full-fed. When they reach the pupae state they are either naked or are covered with a silken cocoon.

It takes a number of days for a full-grown insect to emerge from the pupa.

There are three classes in every nest of ants—the males, the females, and the workers. The workers are imperfect, or undeveloped females. In some cases there seem to be different classes of workers, each class serving some purpose not now clearly understood.

Selecting as large a specimen of an ant as you can find, make a careful study of the parts of its body. Observe the compound eyes. Are the facets of the compound eyes hexagonal? Locate and count the simple eyes. Do you think the eye of the ant has as many facets as the eye of a dragon-fly? You will need a microscope to study the eye of any insect. See if you can make out the mouth-parts, the upper lip, the mandibles, the maxillae, the lower lip, and the palpi. Find on the thorax of a worker ant the points at which the wings should be attached. Distinguish the coxa, trochanter, the femur, the tibia, and the tarsus. These are the parts or segments of the leg of a typical insect. Count the number of rings in the abdomen. Compare this number in male, female and worker. Determine whether or not your specimens have a sting or are stingless. Since the sting is a modified ovipositor, the male ant could possess no sting.

The following is the history of the formation of a new ant's nest: The workers only live through the winter. In spring their first work is to take care of the eggs laid in the autumn previous. The male and female ants which developed from these eggs swarm on a hot summer's day. They take their marriage flight in the sultry air, then light and enter the ground to form new colonies or else are taken by the workers into the old nests. Before they enter the ground their wings are plucked, not, however, to the injury of the ants, as the wings are merely unhinged and come off naturally. The removal of the ants' wings is a wise provision, as the wings are useless underground. The new nests may be in the earth or in mounds built above the earth, known as ant-hills, or may be in hollow trees.

The larvae of ants are fed by the workers with food taken from the workers' stomachs after it has there undergone some mysterious process. The full-grown ant is useful as a scavenger and small dead animals are rapidly eaten if placed upon a populous ant-hill; in fact, the skeleton of a small mammal may be easily obtained if placed within reach of a strong colony of ants. These will rapidly and cleanly strip the bones of whatever flesh

there may be upon them. Ants are fond of honey and of the sweets of flowers.

Ants also capture and keep alive in their nests certain species of aphides which are honey-producing. In this they show an instinct exceedingly striking. They bestow as much care upon the aphides as men do upon their domestic animals, feeding them and tenderly stroking them with their antennae. All this is done for the little drop of sweet juice which the aphides produce. Certain species of beetles may also be found in ants' nests. Nor is the ant free from parasites. Sir John Lubbock tells of a female ant in his possession which for a long time carried beneath her jaws, where she could not get at it, a tiny parasite. What at first thought, also, seems quite strange, is the fact that none of her fellows in the nest offered to remove it. In this case, as in others spoken of by Lubbock, the ants showed no inclination to assist one another when they were in trouble.

Most curious of all the strange things about ants is their custom of taking and holding slaves. In some cases have they become so dependent upon the service of their captives as to be almost helpless without them. Mr. P. Huber gives the following account of how any army of Rufescent ants captured a nest of a different but weaker species. The Rufescent ants "moved in a body with considerable rapidity and occupied a space of from eight to ten inches in length, by three or four in breadth. In a few minutes they quitted the road, passed a thick hedge, and entered a pasture ground, where I followed them. They wound along the grass without straggling and their columns remained unbroken, notwithstanding the obstacles they had to surmount. At length they approached a nest, inhabited by ash-colored ants, the dome of which rose above the grass, at a distance of twenty feet from the hedge. Some of its inhabitants were guarding the entrance; but, on discovery of the approaching army, darted forth upon the advance guard. The alarm spread at the same moment in the interior, and their companions came forth in numbers from their underground residence. The Rufescent ants, the bulk of whose army lay only at the distance of two paces, quickened their march to arrive at the foot of the ant-hill; the whole battalion, in an instant, fell upon and overthrew the ash-colored ants, who, after a short but obstinate conflict, retired to the bottom of their nest. The Rufescent ants now ascended

the hillock, collected in crowds on the summit, and took possession of the principal avenues, leaving some of their companions to work an opening in the side of the ant-hill with their teeth. Success crowned their enterprise, and by the newly-made breach the remainder of the army entered. Their sojourn was, however, of short duration, for in three or four minutes they returned by the same apertures which gave them entrance, each bearing off in its mouth a larva or a pupa."

In some cases the masters have become so dependent upon their slaves that the young cannot be reared without them, and when the slaves are taken entirely away even the old ones starve to death, even in the presence of abundant food.*

Bees.

A glass window placed in a bee-hive, if covered over when it is not wished to observe, will give opportunity to observe the life inside the hive. If light is allowed to shine too long in the glass the bees will begin to daub it over with wax, and thus destroy its usefulness. With a very gentle species, like the Italian bee, the patent drawers containing the comb may be carefully removed, and the queen seen at work depositing eggs in the cell, and surrounded by her royal guard. The whole history of a swarm can thus be traced out.

Those who are looking for the strange and curious will without doubt find more to suit their taste in a careful study of the habits, structure, and life-history of the honey-bee than in that of any other insect. So much has been written, however, about the bee, and so much about it repeated, that we are apt to depend upon books rather than see the wonderful processes with our own eyes..

Procure a number of specimens, with a view, first, to knowing the structure of the bee. To begin with, you will find that the head, which appears to be very intricate in its parts, possesses all the appendages found upon the head of the grasshopper.

* The ants fall into three families: first, typical ants, the formicidae, those in which the peduncle or the connecting piece between thorax and abdomen consists of a single piece; second, the poneridae, those having a peduncle of a single piece but a constriction between the second and third abdominal segments; third, the myrmicidae, those having a peduncle of two segments. The queens and workers of poneridae and myrmicidae have stings, those of the formicidae do not. These characteristics will enable the beginner to classify ants into families.

Look at the eyes through the microscope, and find upon the epicranium three simple eyes arranged in a triangle. Notice how the segments of the antennae vary in length. Locate other mouth-parts—the mandibles, the maxillae, the lower lip, with its palpi; also the maxillary palpi. Notice that the maxillae are hairy, and that the middle prong of the ligula, the distal end of the labium, is prolonged into a tongue which is longer when extended than the maxillae. It will be seen that all of these parts are lengthened so that the insect can readily reach into a flower for sweets. The bee does not suck the juices from flowers, but rather laps them with its long, hairy tongue. The work of the tongue is aided by the palpi and the maxillae, which, with the upper part of the tongue, form a sort of channel in which the liquid is conveyed to the mouth. With a large hand-lens watch the action of the mouth-parts as a bee laps from a drop of honey.

Bees, unlike ants, are usually hairy. Is there any reason you can give for this being so? The bee's legs are specially adapted for carrying bee-bread or pollen of flowers. The bee uses her mandibles to collect this. She uses her front pair of legs as hands with which she takes the pollen from the mandibles and passes it to the second pair of legs. The second pair passes it on to the big basal joint of the tarsi of the hind pair of legs. This joint of the hind tarsi is much enlarged for the purpose of carrying pollen. One may see the yellow pellets of pollen upon the hind legs of bees returning upon summer days to the hive.

Observe and count the segments of the abdomen. Put on a thick buckskin glove, catch a bee, and notice the action of the sting. Does the male bee or drone have a sting? If not, why? Does the queen of the hive have a sting? When does she use it?

There are four substances that the bee deals with. They are honey, pollen, wax, and propolis. The honey of bees consists of the flower-sweets worked over in some mysterious manner in the bee's crop. From the crop it is taken by a muscular process and placed in the honey cells. That some distinct change is made in the juicy sweets taken from the flower is proven by the fact that bees can make honey from sugar and water alone. Pollen is most probably used as a food for the larva, although there is some difference of opinion upon this point. Wax, the substance out of which the honey-cells are made, is secreted

from glands by the worker-bee. The wax-glands may be seen by closely examining the under side of the abdomen of your specimens. The wax is secreted in thin membraneous plates through fine tubes made of chitine. When bees are ready to build new honey-cells or comb, they hang, after gorging themselves with honey, in long strings, each bee clinging to the abdomens or legs of those above her. They remain in these positions very quietly during the secretion of wax.

When they have thus hung for some time the small crescent-shaped edges of wax may be seen projecting from the little flaps called "wax-pockets." The process of secreting being complete, the wax is then collected and kneaded by other worker bees with their jaws. Then begins the construction of a double set of hexagonal cells, each cell being more or less perfect in shape. This collection of cells is what we know so familiarly as honey-comb. The edges of the cells are rounded and somewhat thickened, and colored with a dark red. The material used by the bee to put the finishing touches upon the cell is known as propolis. Propolis is a gummy substance obtained by the bees from certain trees, for example, the horse-chestnut or the poplar. The honey-cells each slope gently from the open end of the cell in order that the worker bee may more readily place the honey in them. When the honey cell is full of honey it is sealed with wax.

Cells in which the young bees are to be reared are filled with pollen, each cell containing from seven to eight bee-loads of it.

Finish your observation of the structure of your specimen by a close study of the wings. Notice their venation. It would be well, by way of review, to compare the veining and other characteristics of the bee's wing with those of the wings of other prominent insect orders, such as the butterfly, the grasshopper, the beetle, the hemipter, the dragon-fly, etc. Mr. J. H. Comstock, the entomologist, has worked out a plan of the venation of wings which shows that the veining is according to certain fixed principles which are valuable in ascertaining the group or class to which an insect belongs.

As with ants, there are three classes to be found in the hive. These are the male or drone, the female or queen, and the worker, which is an undeveloped female. The workers are most numerous, there being sometimes over fifty thousand of this class in a single hive. There are generally about two thousand

drones, with but one queen. A drone is much larger than a worker, and has no sting. He may be recognized by an experienced ear by his low, lazy hum when flying. The queen may be recognized by her pointed abdomen, by her short wings and by the manner in which the wings cross each other when she is at rest. One accustomed to working with bees can easily find where the queen is in the hive, as there is always about her a cluster of bees with their heads towards her. Wherever she goes, they never turn their heads from her, but are always present to keep a clear space for her, moving backwards or sidewise as she moves.

In the spring of the year a queen who, with a greater or less swarm of workers, has survived the winter, begins by laying eggs first in the worker cells, then in the drone cells. Then the eggs from which the queens are hatched are laid. In early summer the flask-shaped queen-cells are constructed by the workers, and the queen-larvae which are reared in these are fed with the choicest nectar. When one of the young queens is full grown and comes from her cell, the old queen first attempts to kill her rival, but being prevented by the workers, she leaves the hive, taking with her a sufficient number of workers to start a new colony. This exodus from the old hive is known as swarming. The young queen of the old hive takes her marriage flight in the air with a drone, and on returning to the hive assumes charge. When a second young queen is matured, the first young one leaves with a second swarm. Thus the formation of new swarms is repeated.

In case a hive loses its queen, there is straightway great consternation. The workers examine the comb for queen cells. If there are none and if there are no worker-cells containing eggs from which a queen may be developed, the swarm ceases to work and dies when the honey in the hive has been eaten. If cells are found containing worker eggs order is restored, and one of the cells is enlarged by taking down the wax partitions between it and two adjoining cells, the eggs in the adjoining cell being destroyed. Over the third egg a queen cell is built and when it hatches the larva is fed with royal jelly, a very rich food excreted from the workers' mouths. If, when a queen dies, there are still queen cells unopened, the work of the hive goes on as usual till a queen is hatched.

When all the young queens are full-grown and have, with the exception of the last, gone with their respective colonies, the workers pounce upon the drones and sting them to death without mercy.

If perchance two queens hatch at the same time a contest ensues, which ends in the weaker or less agile being stung to death. It is said that, by a wise provision of nature, the anatomy of the queens is such that two fighting cannot possibly sting each other at the same time, so the hive cannot possibly be left without a head by a duel fatal to both. It is in these contests only that the queen uses her sting.

The drone lives but a summer; the life of the worker is about eight months, while a queen has been known to live five years, and during this time it is estimated that she has laid a million of eggs.

The eggs from which drones hatch are laid by unfertilized queens or even by worker bees. The eggs laid by the queen are nearly pure white and are cylindrical in shape. The queen lays but one egg in a cell, while a worker bee, if it does lay, will deposit six or seven in a single cell. The egg hatches into a larva, which in turn becomes a pupa, which finally changes to the full-grown insect.

I have spoken before of the sting of the worker. According to Wood, the poisonous fluid of the sting "is secreted by two very delicate poison glands, which resemble threads, not nearly so thick as a human hair, and white in color. These glands unite together at their bases and form a common tube, which opens into the poison sack, in which the venom is retained until it is wanted. The base of the sting is connected with the poison sack, and as soon as the weapon is used, the poison flows down the sting and is injected into the wound."

The bumble bee is one of the most interesting of membrane wings to be found in California. In the spring of the year it may be seen flying busily from flower to flower. The male may be caught very easily and is harmless, but the female is very ferocious and uses its large sting with painful effect. The honey-bag of the bumble is large enough to hold a good-sized drop of honey, and this may be pressed out, after the bee is killed, by a gentle pressure. This honey is very palatable, and I have spent many an hour, when a boy, in killing the bees for the drops of

honey I could get from them. Bumble bees build their nests in deserted mouse nests, under rocks or in any suitable cranny or crevice they can find. The queen bumble bees, who alone survive the winter, each start a new nest or colony. Selecting a deserted mouse nest in a meadow she collects and places in it a ball of pollen. In this ball she lays her eggs. When the young bumble bees hatch they eat the pollen till full fed. Then they spin silken cocoons in which to undergo their transformations. Finally they emerge as workers. In the meantime the queen has strengthened the cocoon walls with wax, and when the cocoons are empty she uses them as honey cells. Thus there is no regular arrangement of bumble bee honey-comb. After the hatching of the first brood in the spring the queen gives all her time to egg-laying, while the young workers collect the honey and pollen.

The last eggs of the season produce both males and females, which perpetuate the swarm for the next year. The largest number of bees at any one time in the nest is about 400. They are all covered with heavy hair and are brilliantly colored with yellow and black. There are about forty different species in North America.

Wasps.

In the spring of the year, if you will keep a square yard or two of ground quite damp by wetting it frequently, you will soon find that it is visited by a large winged insect which, by its membrane wings, you will recognize as a relative of bees and ants. This insect is known as the Mud Wasp, for it is of mud that it builds its nest. When the wasp lights it will commence at once to knead with its mandibles a lump of mud about the size of a No. 1 shot. While it works it continues to hum, making a noise very much like the buzz of a large fly that is caught in a spider's web. When the mud is sufficiently worked over, the humming ceases and away the wasp flies to its nest, which is very often built in the roof of an old shed. Here the mud is built into a round cell which is just large enough to receive the wasp's body. The trip to the moist ground is continued until the cell is finished. An egg is deposited in it and it is filled with young spiders and carefully sealed. Should a hole be made in the cell the mother wasp will at once repair it. I have nests as large as a hen's egg, made up of cells such as I have described. The

amount of work required to build a nest of this size seems almost incredible when we think how small the workman is. When the egg hatches the young wasp lives on the spiders, which live in a comatose condition, being stung when placed in the cell by the mother wasp, but not killed outright. When the spiders are all eaten the young wasp becomes a pupa and soon breaks the cell open, emerging a perfect wasp.

The mud wasp, since it lives only with its mate, is known as a solitary wasp. Our common wasp, since it lives with numbers of its fellows in or about a single nest, is considered as belonging to the division known as social wasps. The life history of the common wasp may be observed by capturing a nest, together with the old ones, and putting it into a glass fruit jar. The whole colony will flourish on a little sugar and water. In course of several weeks the development of an individual may be seen from the time the egg is first deposited till the seal of the cell is broken and the full-grown insect escapes to make one of the swarm. There are some very interesting things to be observed in the anatomy of wasps. Notice the peculiar way in which the front and back wings are fastened together, giving the appearance of a single pair of wings instead of two pairs, as there really are. Notice the very narrow "waist" connecting thorax and abdomen. Notice the action of the spiracles in breathing. Would it drown an insect to put its head under water? Notice how wasps stand upon the surface of water upon a hot, sunshiny day. Why do they not sink? Can you explain how it is that they can thus stand on the surface of the water? Notice how the old wasps feed the young.

The common wasp builds her nest of wood kneaded into a pulp which, when it hardens, is very similar to paper; so I suppose we must consider that the wasp was the first paper maker. What kind of wood should you supply your pets so that the continued nest-building may go on? The cells are hexagonal in shape, but are not filled with honey, being used solely for the rearing of young. The cells hang perpendicularly in a horizontal comb, the comb being covered with a sort of paper umbrella. A second comb of cells may be attached to the first by means of paper columns, the umbrella cover being enlarged each time more cells are built. The first wasps to hatch are workers which aid in taking care of the swarm. The last brood is made

up of both males and females. The females alone live through the winter to perpetuate the swarm in the next spring.

In connection with hymenoptera the ichneumon flies deserve special notice for the reason that they spend their larval state within the body of some other insect. It is not surprising, therefore, that they are very useful in destroying insect pests. In many of them the ovipositor is singularly developed and is often used as a weapon of defense though no serious injury can result from it as it has no sting.

One ichneumon is well known as the destroyer of the common cabbage caterpillar. Nearly every caterpillar of this kind will be found to have one or more of the larvae of the Microgaster in its body. The skin of a sting caterpillar is sometimes filled with litle grubs of the caterpillar. The fat of the caterpillar being eaten by the young parasite, the former is not able to develop into pupa state. When the caterpillar is full-grown the grubs burst the skin and leave their host to die. Strange to say, the ichneumon eats only fat from its victim, leaving the vital parts untouched. When the caterpillar finally dies the parasite passes its transformations in the dead skin.

There is also a tiny ichneumon which is parasitic on the aphis. It usually strikes the insect from the back, and when the egg is deposited the wounded aphis leaves his friends, attaches himself to a leaf and dies. Numbers of dead aphidae can be seen at the end of the season attached to leaves in this way. A tiny round hole in the skin shows how the work was done.

APPENDIX.

Remedies for trees infected with injurious insects may be classified as follows: First, those which kill the insects by poisoning, as cyanide of potassium, arsenic, and so on; second, those which eat away the coverings of insects, as lye, potash, et cetera; third, those which kill by penetration, as kerosene; fourth, those which shut off the supply of air, as whale-oil soap; fifth, beneficial insects; sixth, beneficial animals; seventh, mechanical arrangements, as the triangular scraper, to be used for cleaning trees.

The surest insecticide is cyanide of potassium. Cover the infected tree with a tent which is entirely opaque. The generator is an earthen jar into which is placed three ounces of water by measure; to this is added, at the same time but from separate vessels, one and one-half ounces of cyanide of potassium by weight, and one and one-half ounces by weight of sulphuric acid. A piece of heavy sacking may be placed over the jar to prevent the too rapid escape of the gas. Each tree should be exposed for fifteen minutes. The cost of application is six cents per tree. It may be remarked that in the case of very large trees the application of this remedy is difficult.

One pound of paris green dissolved in ammonia, to one hundred and fifty gallons of water, is an excellent spray for the codlin moth. Spray just after the blossoms have fallen, not sooner, as bees and their honey may be injured, and not very much later, as the apples may be rendered unsafe. Two applications of this remedy are considered necessary.

Remember that buhach, tobacco, sulphur, and lime are all good insecticides. Every farmer should raise a small patch of tobacco, to be used in battling insects.

Kerosene destroys pests by penetrating them, and will, if strong enough, destroy scales when other means have failed. Great care must be taken, however, or it will destroy both tree and pests. To weaken kerosene it is mixed with milk. The mixture is called an emulsion. There is less danger in spraying the tree with kerosene emulsion in winter when the leaves are off and the tree is dormant. The milk emulsion is made by violent churning. By this a homogeneous mixture is produced, which may be thinned at first with small quantities of water and afterwards with quantities to suit. Low grades of kerosene should not be used.

Those who wish to be sure of the best remedies for insects should consult the Reports of the United States Secretary of Agriculture, also the Farmers' Bulletins issued by the same department. The Reports of the California State Board of Horticulture should also be consulted.

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Studies in entomology.

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